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SNAKE RIVER BIRDS OF PREY RESEARCH PROJECT

ANNUAL REPORT 1986

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
BOISE DISTRICT
IDAHO

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SNAKE RIVER BIRDS OF PREY RESEARCH PROJECT

ANNUAL REPORT

1986

Karen Steenhof and Michael N. Kochert
Editors

NOT FOR PUBLICATION

The data presented herein are preliminary and may be inconclusive. Permission to publish or cite any of these materials is therefore withheld pending specific authorization of the Boise District, BLM, and the specific Principal Investigator.

Michael N. Kochert
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PREFACE

This report summarizes research and monitoring activities in the Snake River Birds of Prey Area during calendar year 1986. Much work in 1986 was directed towards technology transfer; however, significant effort was dedicated to continuing the cooperative research. The 2 cooperative studies with Pacific Power and Light Company and the 1 with Idaho Power Company that were initiated in 1984 were continued this year. In addition, 15 scientific articles and/or chapters were published and/or accepted for publication in 1986, and Birds of Prey Project staff members and associates made 16 technical presentations at meetings.

As a result of concern about the effects of numerous fires in the BOPA in recent years, 2 cooperative studies were initiated in 1986. One study with The College of Idaho assessed Townsend groung squirrel abundance in different habitat types. A cooperative study with The Nature Conservancy's Idaho Natural Heritage Program assessed small mammal abundance in burned and unburned habitats. Other 1986 field activities included continuing investigations of common barn-owl feeding ecology by Dr. Carl Marti, the association of mycorrhizae with desert shrubs by Dr. Marcia Wicklow-Howard, nest box use, reproduction and food habits of western screech-owls by John Doremus and Jeff Marks, and nest box use by American kestrels by Karen Steenhof and Craig Groves.

Basic monitoring of the vegetation and certain prey and raptors continued in 1986. This year raptor monitoring focused on occupancy surveys of prairie falcons and red-tailed hawks which will be done every other year and occupancy and productivty assessments of golden eagles which is being done annually. Monitoring work was conducted by the research staff and Bruneau Resource Area personnel.

Results of the 1986 field season of these research, study, and monitoring efforts are presented in this report.

ACKNOWLEDGMENTS

The Bureau of Land Management wishes to thank those agencies and individuals who assisted with the project. Appreciation is extended to the Idaho Department of Fish and Game and the U.S. Fish and Wildlife Service for special permits and assistance. Special thanks go to all other individuals who volunteered their services.

Special appreciation is extended to Mr. E. T. Evans for providing the area for the Melba field camp and other assistance. Terri Thomason deserves special thanks for typing the manuscripts.

COOPERATING AGENCIES AND INSTITUTIONS

Boise State University
College of Idaho
Idaho Department of Fish and Game
Idaho Power Company
Idaho State University
The Nature Conservancy
Pacific Gas & Electric Company
Pacific Power and Light Company
Shoshone District, Bureau of Land Management
University of Idaho
University of Wisconsin
U.S. Fish and Wildlife Service
Vale District, Bureau of Land Management
Weber State College
World Center for Birds of Prey

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PART I

TECHNOLOGY TRANSFER

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9/4/86 Roppe, J.A. 500 kV raven study. Annual Meeting of the Utilities Design and Appearance Committee, Portland, Oregon.

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11/23/86 Holthuijzen, A.M.A., A.R. Ansell, M.N. Kochert, L.S. Young and R.D. Williams. Breeding prairie falcons (Falco mexicanus) and industrial construction: a contradiction? Poster presentation. Annual Meeting of the Raptor Research Foundation, Gainesville, Florida.

PART II

PROGRESS REPORTS

TITLE: Occupancy and Productivity of Golden Eagles, Prairie Falcons, Red-tailed Hawks, and Ferruginous Hawks in the Snake River Birds of Prey Area.

INVESTIGATORS: Michael N. Kochert, Research Leader
Karen Steenhof, Associate Research Leader
John H. Doremus, Wildlife Biologist, Bruneau Resource Area
Randy M. Trujillo, Wildlife Biologist Bruneau Resource Area
Nina Walker, Volunteer
Lydia Kading, Volunteer

OBJECTIVES:

1. To determine occupancy, nesting success, and productivity at traditional golden eagle (Aquila chrysaetos) and ferruginous hawk (Buteo regalis) nesting territories.

2. To compare occupancy and productivity of golden eagle pairs in the Birds of Prey Area (BOPA) with those of eagle pairs in the Comparison Area.

3. To monitor occupancy of prairie falcons (Falco mexicanus) and red-tailed hawk (Buteo jamaicensis) pairs in 8 randomly selected 10-km river units in the BOPA.

4. To continue to record movements of banded and wing-marked raptors and ravens.

ANNUAL SUMMARY

The number of occupied golden eagle territories in the BOPA was slightly lower than in 1985; however, productivity in the BOPA was slightly higher than 1985, the lowest ever recorded. As in 1985, eagle productivity was much lower in the BOPA than in the Comparison Area. In 1986, 8 10-km river units were monitored for prairie falcon and red-tailed hawk occupancy. The data suggest that declines in the number of occupied prairie falcon territories occurred in Units 6 and 26. No appreciable declines occurred in the remaining 6 units. Red-tailed hawk numbers were greater than in previous years. Ferruginous hawk productivity (young fledged/pair) was lower than recorded in 1985.

METHODS

Golden eagle territories in the BOPA and Comparison Area (Fig. 1) were surveyed for occupancy from a Hiller/Soloy jet helicopter on 19 March. Some territories near the Pacific Power and Light Co. (PP&L) 500 kV transmission powerline were also checked from a Bell 206B Jet Ranger on 10 April and from a Hiller/Soloy on 6 May. Territories where breeding status could not be determined during the March helicopter flight were subsequently surveyed from the ground for signs of occupancy or breeding (see below for criteria). Territories containing breeding pairs were checked for productivity from a Hiller/Soloy on 5 June and from a Jet Ranger on 16 June.

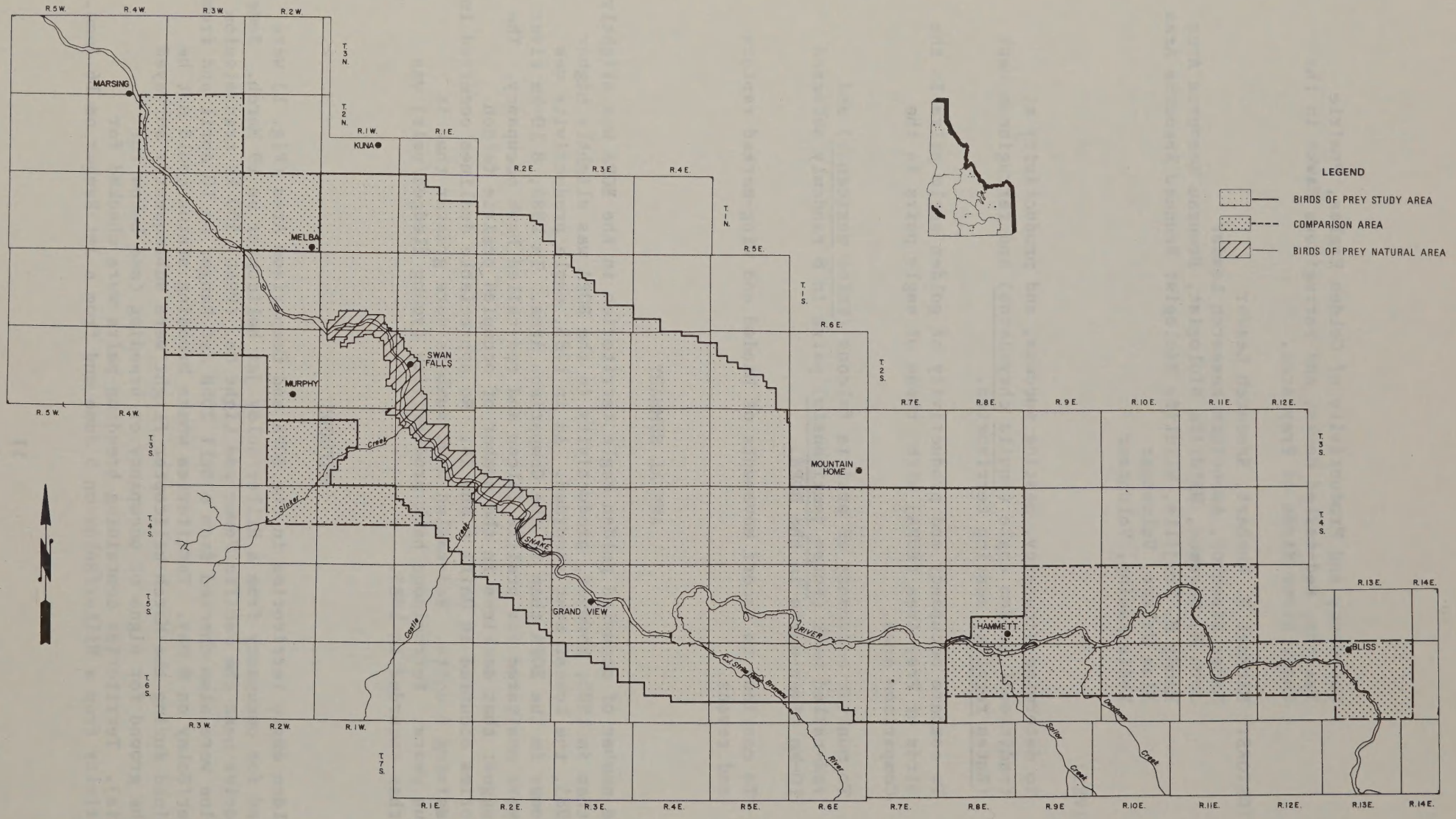

Fig. 1. LOCATION OF THE BIRDS OF PREY STUDY AREA (BPSA) AND COMPARISON AREA

Eight 10-km river units in the BOPA (numbers 3, 6, 7, 8, 15, 24, 26, and 37) were selected using stratified random sampling; strata were based on falcon density in earlier years (Fig 2). The units were searched on foot and by boat once each month from March through June for occupied prairie falcon and red-tailed hawk territories. Results were contrasted with findings from 1976-1978, the years when all of these 10-km units were thoroughly surveyed. Because of the high cliffs in this stretch it is uncertain whether surveys were intensive enough to confirm vacancy of territories on the south side of the river in Unit 6 between the mouth of Sinker Creek and Balls Line West. Therefore, this stretch was excluded from the analysis.

We attempted to ascertain the breeding status and nesting success of all eagle and ferruginous hawk pairs located prior to hatching. Additional information on reproduction was obtained from other pairs found later in the season. Productivity data on ferruginous hawks were collected incidental to the falcon, red-tailed hawk, and eagle surveys. Eagle pairs that showed no evidence of egg laying after repeated observations or after climbing into and examining potential nests were categorized as "nonbreeding." A "breeding attempt" was confirmed if an occupied territory contained an incubating adult, eggs, young, or any other indication that eggs were laid (e.g., fresh eggshell fragments in fresh nesting material). A breeding attempt was "successful" it produced 1 or more young that reached fledging age (i.e 51 days for golden eagles and 33 days for ferruginous hawks (Steenhof 1987)). Eagle nests discovered after young had fledged were considered successful if: 1) a platform decorated this season was worn flat and contained fresh prey remains, 2) fresh fecal matter covered the back and extended over the edge of the nest, and 3) no dead young birds were found within a 50-m radius of the nest.

Nesting Density

Golden Eagles

In 1986 golden eagle pairs occupied 29 (78%) of the 37 traditional eagle nesting territories in the BOPA. Number of occupied territories decreased by 3 from 1985, but was 2 more than in 1983, the year of lowest eagle density in the BOPA. As noted in previous years, some of the territories may have become permanently unsuitable for nesting. Five of the 8 vacant territories have not been occupied since 1982, and 4 have been vacant for the past 7 years. One of these, "Bruneau Flats," has not been occupied since 1976. The Swan Dam territory, vacant from 1980 through 1984, was reoccupied in 1985 and 1986. Occupancy in the Comparison Area was slightly better than in the BOPA with 23 of 26 traditional territories (88%) being occupied.

Prairie Falcons

Sixty occupied prairie falcon territories were located in the 8 survey stretches in 1986 (Table 1). From 1976 to 1978 the number of pairs found in those same stretches averaged 70.3 (range 65 to 74). The 1986 density represents a 14.6% decrease from the 1976-1978 average and a 7.7% decrease from the 1978 level. The 1978 level was identified as the "minimum expected

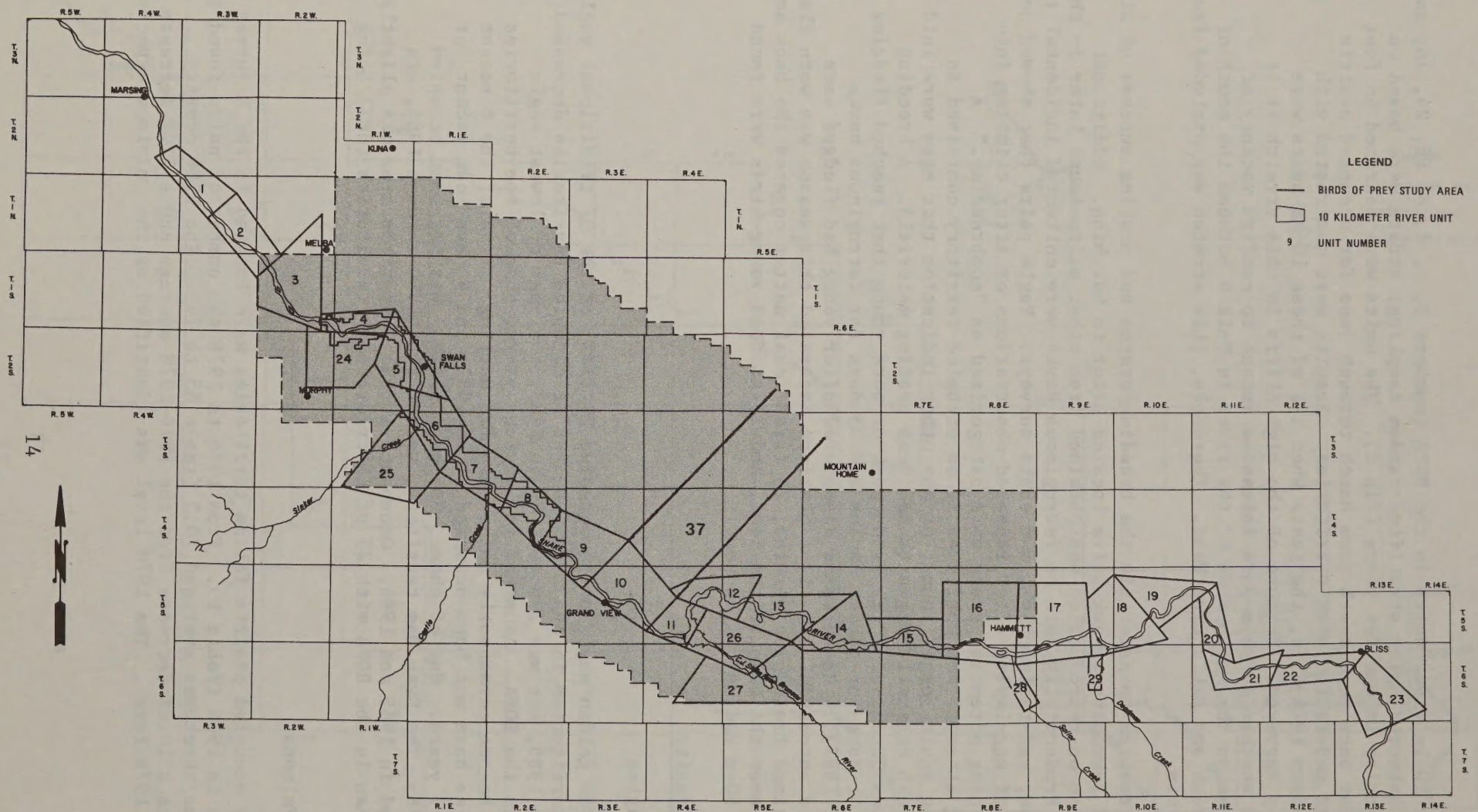

Fig. 2. 10 KM RIVER UNITS ALONG THE SNAKE RIVER, BPSA AND COMPARISON AREA

Table 1. Number of occupied prairie falcon territories in randomly selected 10 km units in the BOPA, 1976-78, and 1986.

10 km Unit	1976	1977	1978	1976-78 ($\bar{x}$)	1986
3	0	0	1	(0.3)	0
6*	23	25	21	(23.0)	19
7	12	11	14	(12.3)	11
8	14	13	9	(12.0)	11
15	13	13	13	(13.0)	13
24	3	4	2	(3.0)	2
26	4	5	3	(4.0)	1
37	3	3	2	(2.7)	3
Total	72	74	65	(70.3)	60

* Excluding the south side of the river between the mouth of Sinker Creek and Balls Line West.

number of nesting pairs" in the Birds of Prey Management Plan (U.S. Dep. Inter. 1985).

The decrease in number of pairs found in 1986 did not occur uniformly throughout the area; 6 of the 8 units showed no substantial change from previous years. The numbers of occupied territories in Units 3, 15, and 37 were the same as the 1976-1978 average density. Units 8 and 24 were 1 pair lower than the 1976-1978 average density, but both were within the 1976-1978 range. Unit 7 showed a drop of 2 pairs from the 1976-1978 average, but the 1986 density was also within the 1976-1978 range.

To supplement the comparison with 1976-1978 densities, we examined data from 3 units (7, 8 and 15) that had been surveyed each year from 1976 to 1983 (Table 2). In each of these 3 units, the number of pairs found in 1986 was within the range of densities observed between 1976 and 1983. The 1986 count was slightly lower than the long term average in Units 7 and 8, but the 1986 total was higher than the average in Unit 15.

Units 6 and 26 accounted for the greatest decrease in number of observed falcon pairs from 1976-1978 levels (Table 1). Sixty-eight percent of the decline observed in all 8 units (7.0 of 10.3 territories) occurred in Units 6 and 26. Unit 6 declined from an average of 23 pairs in 1976-1978 to 19 pairs in 1986; Unit 26 declined from 4 pairs to 1.

Red-tailed Hawks

In 1986, 31 occupied red-tailed hawk territories were found in the 8 survey stetches (Table 3), an increase of 25.7 territories over the 1976 to 1978 average in these same stretches. Number of pairs found in Units 3, 8, 24, and 26 increased from the 1976-1978 levels. Unit 15 was the only stretch where number of pairs decreased. Units 6, 7, and 37 showed no change.

Reproduction

Golden Eagle

Golden eagle reproduction in 1986 was slightly higher than in 1985, the lowest ever recorded in the BOPA. Percent of pairs breeding increased from 38% in 1985 to 45% in 1986, percent of pairs successful increased slightly from 16% in 1985 to 21% in 1986, and young fledged per pair increased slightly from 0.16 young per pair in 1985 to 0.27 in 1986 (Table 4). In 1986 only 8 young eagles fledged from the BOPA. Only 2 of 6 successful pairs fledged 2 young; the remaining 4 fledged only 1 each. Productivity in 1986 is still lower than the next lowest year (1973) when only 67% of the pairs laid eggs, and 30% of the pairs successfully raised young that fledged for an average of 0.43 young per pair.

Reproduction of golden eagles was higher in the Comparison Area than in the BOPA in 1986 (Table 4). Of pairs occupying territories in the Comparison Area, 62% laid eggs and 38% successfully fledged young, for an average of 0.57 young produced per pair. This fledging rate is more than twice that recorded in the BOPA.

Table 2. Number of occupied prairie falcon territories in 10-km survey units numbers 7, 8, and 15 in the BOPA, 1976-83, and 1986.

Year	7	8	15	Total
1976	12	14	13	40
1977	11	13	13	39
1978	14	9	13	37
1979	15	10	11	36
1980	13	11	10	34
1981	15	14	12	41
1982	11	12	8	31
1983	11	15	15	41
1986	11	11	13	35
Mean	13.1	12.2	11.8	37.1

Table 3. Number of occupied red-tailed hawk territories found in randomly selected 10-km river units in the BOPA, 1976-1978, and 1986.

10 km Unit	No. Occupied Territories			
	1976	1977	1978	1986
3	1	1	1	4
6	7	8	6	7
7	7	6	5	6
8	4	4	4	5
15	4	5	5	3
24	2	1	1	3
26	1	1	1	3
37	1	0	1	1
Total	27	26	24	32

Table 4. Nesting success and productivity of golden eagles and ferruginous hawks in the BOPA and Comparison Area, 1986. Sample sizes are in parentheses.

Species	% of Pairs Breeding	% of Attempts Successful	% of Pairs Successful	Number of Young/ Successful Attempt	Number of Young Fledged/ Pair
Golden Eagle BOPA	45 (29)	38 (16)	21 (29)	1.33 (6)	0.27
Golden Eagle Comparison Area	62 (21)	62 (12)	38 (21)	1.50 (8)	0.57
Ferruginous Hawk BOPA*	--	64 (14)	43 (21)	2.43 (14)	1.04

* Includes 3 pairs on the PP&L power line within the BOPA.

Red-tailed Hawks

Of the 31 pairs located in the 8-10 km units, 10 were found during incubation, and breeding success was ascertained for 9 of them. Six of 9 (67%) nesting attempts successfully fledged an average of 1.34 young per nesting attempt. Four successful nests fledged an average of 2.00 young per successful pair.

Ferruginous Hawk

In 1986, 28 pairs were observed in the BOPA; 3 were in territories not previously occupied by ferruginous hawks. Twenty-two occupied territories were found during the incubation period, and success was determined at 21 of them. Nine (43%) fledged young for an average of 1.04 young per pair (Table 4). Breeding was confirmed at 14 territories; only 64% of these were successful. Number of young fledged per successful attempt averaged 2.43 (Table 4).

Nesting success of ferruginous hawks varied with nesting substrate. On natural substrates (e.g., cliff and ground), 5 of 9 (56%) breeding pairs were successful. Only 1 of 4 (25%) pairs that built nests on the IPC 138 kV wooden transmission poles was successful. This low productivity was attributed to weather and unstable substrate. These nests were in the wood crossarms of the "H" design poles, and 3 of the 4 were blown out by wind. Six of 8 (75%) ferruginous hawk pairs nesting on the PP&L steel transmission towers successfully fledged young (see PP&L Nesting Study in this report).

Banding and Marking

During 1986, 142 raptors and ravens were banded with aluminum U.S. Fish and Wildlife Service bands under the BLM Master Station Banding Permit. This includes 36 prairie falcons, 4 ferruginous hawks, 34 American kestrels (Falco sparverius), 5 Cooper's hawks (Accipiter cooperi), 17 western screech-owls (Otus kennicottii), 5 northern saw-whet owls (Aegolius acadicus) 3 great horned owl (Bubo virginianus), and 38 common ravens (Corvus corax). All of the ferruginous hawks and great-horned owls were banded as nestlings. The screech-owls and saw-whet owls were banded as part of the screech-owl study (Screech Owl Study in this report), and the kestrels were banded as part of the kestrel nest box study (see Kestrel Study of this report). Twelve adult and subadult ravens received backpack radio transmitters and wing markers, and 1 adult received only a leg band. The remaining 25 ravens were nestlings, 3 of which received transmitters and wing markers (see the PP&L Raven Roosting Study in this report).

Band Recoveries and Sightings of Marked Birds

We received reports of band recoveries for 1 golden eagle, 1 prairie falcon, 2 ravens, 3 American kestrels, and 3 northern saw-whet owls. We also had 51 recoveries of 15 different western screech-owls. The eagle was 5.9 years old and was found electrocuted in the Strike I eagle territory, 36 km west of its natal nest in the BOPA. The prairie falcon was recovered as a nestling. Two of the 3 kestrels were recaptured in their nest boxes as adults, and the third was banded as a nestling and was killed by an

automobile 23 km from its natal box. One raven was recovered 1.2 years after banding 1.8 km from its natal nest, and the other was recovered 1.2 years after banding 293 km from its natal nest.

ACKNOWLEDGMENTS

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TITLE: Raptor and Raven Nesting on the PP&L Malin to Midpoint 500 kV Transmission Line.

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OBJECTIVES:

1. To identify all occupied raptor and raven nests on the first 371 miles of the PP&L Malin to Midpoint 500 kV transmission line.

2. To ascertain nesting success and productivity of raptors and ravens nesting on the first 133 miles of the line.

3. To ascertain nesting success and productivity of golden eagles and ferruginous hawks nesting on natural substrate near the intensively studied portion of the line for comparative purposes.

4. To identify preferred nesting locations on the towers and to document how these locations relate to nesting success and possible contamination.

5. To assess physiographic features that may influence use of towers by nesting raptors and ravens.

INTRODUCTION

Electrical power lines have affected raptors both adversely and beneficially (Olendorff et al. 1980, 1981; Nelson 1982). One of the principal benefits of power transmission lines is that they provide nesting substrate for birds of prey (Gilmer and Wiehe 1977; Stahlecker 1979; Lee 1980; Nelson 1982; Kochert et al. 1984). Utilization of transmission lines by nesting raptors and corvids is common, especially in western North America but also in other parts of the world (R. Metcalf, J. Ledger, pers. commun.). The use of power lines by large birds has raised the following questions: 1) Does nesting interfere with power transmission? 2) Can raptor nesting density and success be enhanced by the presence of transmission lines? and 3) What types of tower designs and modifications can minimize interference with transmission and at the same time increase raptor nesting density and success?

The construction of a 500 kV transmission line across southern Idaho and Oregon in 1980-81 provided government and industry biologists with an opportunity to investigate these questions. The Pacific Power & Light

Company (PP&L), in cooperation with the Bureau of Land Management (BLM), agreed to construct 37 artificial nesting platforms (Nelson and Nelson 1976) along its 500 kV transmission line between Midpoint (Jerome), Idaho and Malin, Oregon (Fig. 1). Pacific Power & Light representatives, interested individuals, and BLM Birds of Prey Research biologists have surveyed the line since 1981. This report presents findings of the 1986 survey.

METHODS

Surveys were conducted in 3 study areas in 1986. The "intensive survey area" consisted of Miles 0-133 of the transmission line, and the "extensive survey area" consisted of Miles 134-371 (Fig. 1). To compare nesting success and productivity, golden eagles and ferruginous hawks were surveyed in a third "canyon study area" extending along the Snake River and its major tributaries from Glenns Ferry to Mile 135.

The entire line was surveyed from a Bell 206B Jet Ranger helicopter on 9 and 10 April to locate incubating pairs. Three eagle nests in the canyon were also checked during April survey. Follow-up surveys of the intensive study area were conducted from a Hiller/Soloy helicopter on 6 May and 5 June and a Bell Jet Ranger on 27 May and 16 June. The extensive area was re-surveyed on 21 May from a Bell 206 Jet Ranger. Thirty-eight traditional golden eagle nesting territories in the Snake River Canyon were checked from a Hiller-Soloy on 19 March, and some were re-checked on 6 May. All other occupied eagle and ferruginous hawk nesting territories in the canyon were re-checked for productivity during helicopter surveys on either 5 or 16 June. During all surveys helicopters were flown at speeds of 70-95 km/hr; we usually hovered approximately 20 m from nests for 5-25 sec to view nest contents. Some nests were photographed from the helicopter, and some were subsequently observed from the ground.

Pairs were considered "breeding" if they laid at least 1 egg; this was confirmed by observing eggs, young, or an incubating adult. Because aerial surveys covered only the power line structures, some nonbreeding pairs could have been missed. We considered a breeding attempt successful if 1 or more young reached 80% of the average age when most young normally leave the nest. Nestlings were aged by comparison with photographs of known-age chicks (Moritsch 1983, 1985; BLM, unpubl. data).

We assessed topographic characteristics, cultural features, and land use from topographic maps, aerial photos, and PP&L plan and profile maps of the intensive survey area. For 49 nests where breeding attempts occurred in 1986 and for 71 randomly selected towers that were not used for nesting, we calculated the amount of shrub, grass, and agricultural land within a 1 km radius of each nest and each randomly selected tower. We also assessed the presence and amount of roads, cliffs, buildings, and smaller power lines in the same radius, and we calculated the distance from the tower to the nearest road. The maintenance road following the transmission line was excluded from the analysis.

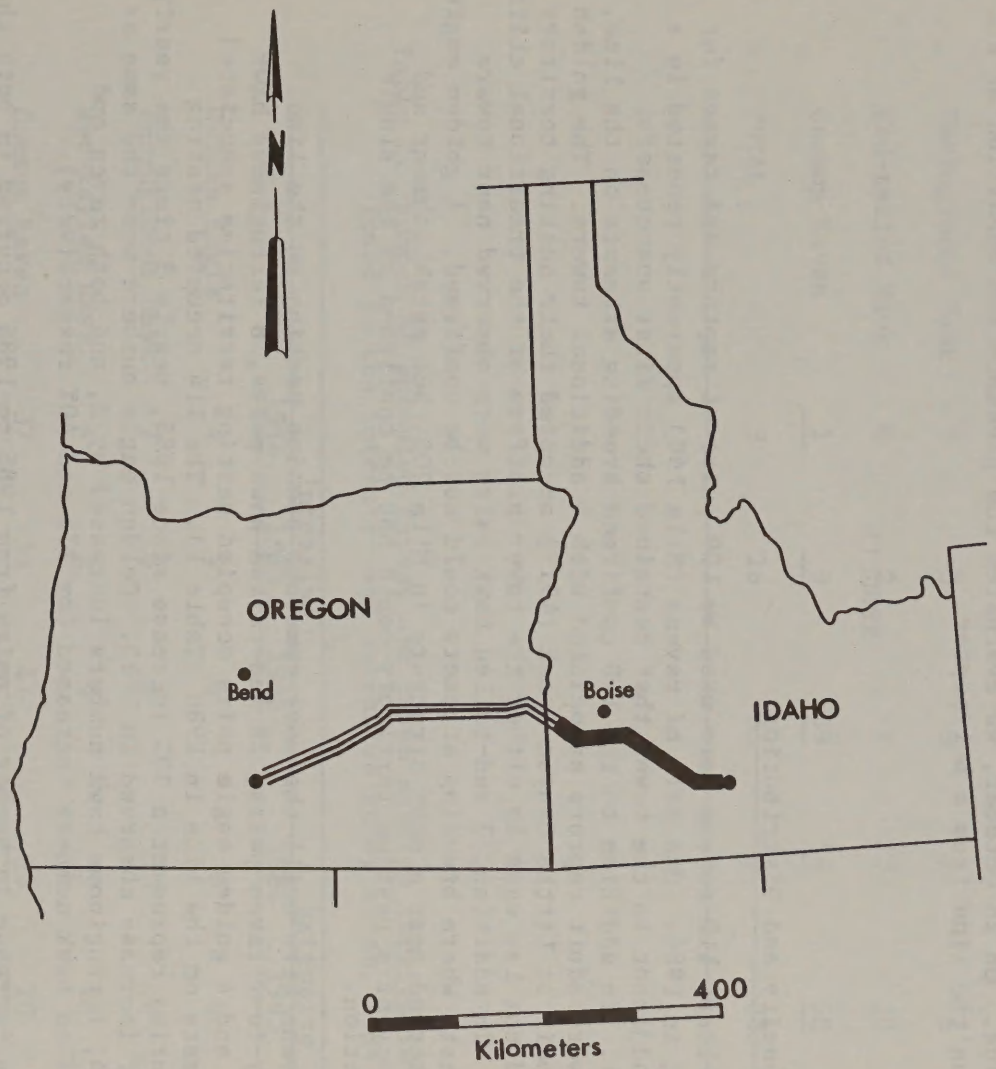


Fig. 1. Location of the Pacific Power and Light 500 kV transmission line. Intensive survey stretch is shaded.

During our helicopter surveys, we described the topography within a 1-tower span radius of 110 nesting and 102 randomly selected towers as either flat (plateau), rolling, canyon/cliff, or valley floor. We also classified land use within the same radius as "agricultural" if 50% or more of the area was farmed, "range" if less than 10% was farmed, and "mixed" if between 10 and 50% was farmed.

Nest heights and tower types were tabulated from PP&L plan and profile maps. Topographic variation around each tower was calculated as the difference in elevation between the lowest and highest points within the 1 km radius. On 28 October, we evaluated the presence and condition of all nests on the line from a helicopter.

RESULTS

Nest Density and Distribution

At least 110 towers were used by 109 pairs of raptors and ravens for nesting in 1986. One pair of ravens (Mile 160) apparently renested in a tower adjacent to the tower that contained their first unsuccessful attempt. In addition to the 110 confirmed breeding attempts on the line, there were adult raptors associated with 4 additional towers. The golden eagle pair at Little Canyon Creek (49/3) occupied their nesting territory but did not lay eggs in either the tower platform or the traditional cliff nests. In addition, 3 red-tailed hawk pairs were observed near towers with nests where breeding attempts could not be confirmed. A golden eagle was observed near a nest structure in Mile 205, but establishment and occupancy of a nesting territory could not be confirmed by the single observation.

Ravens were still the most numerous species nesting on the line. Seventy-four raven pairs, 28 red-tailed hawk pairs, 8 ferruginous hawk pairs, and 4 golden eagle pairs occupied nesting territories associated with nests on the line in 1986 (Table 1). The 114 occupied nesting territories represent a 30% increase since 1985, nearly 3 times the yearly rate of increase observed in 1985. Golden eagle numbers were the same as in 1984, ferruginous hawk numbers increased by 2, and both raven and red-tailed hawk numbers increased (by 27% and 40% respectively).

The increase in number of pairs from 1985 to 1986 occurred in both the intensive and extensive areas (Table 2). The number of pairs in the intensive area increased by 26% while the number in the extensive area increased by 34%. As in past years, overall nesting densities were higher in the intensive study area (0.29 per km; 0.47 per mi) than in the extensive area (0.13 per km; 0.22 per mi), but the difference in densities was not as great as in past years. For the entire line, densities averaged 0.19 nests per km or 7 nests for every 100 towers.

Red-tailed hawks were the least abundant nesting species in the intensive area, but they were almost as common as ravens in the extensive area (Table 2). Ferruginous hawks and golden eagles did not nest in the extensive area.

Table 1. Number of occupied raptor and raven nesting territories found on the PP&L Malin to Midpoint 500 kV transmission line, 1981-86.

Species	1981	1982	1983	1984	1985	1986
Golden Eagle	1	2	5	4	4	4
Ferruginous Hawk	1	3	9	7	6	8
Red-tailed Hawk	0	2	2	13	20	28
Common Raven	1	9	39	55	58	74
TOTAL	3	16	55	79	88	114

Table 2. Number of occupied raptor and raven nesting territories found in the intensive and extensive study areas, 1984-86.

	Intensive			Extensive		
	1984	1985	1986	1984	1985	1986
Golden Eagle	4	4	4	0	0	0
Ferruginous Hawk	7	6	8	0	0	0
Red-tailed Hawk	4	2	4	9	18	24
Common Raven	37	38	47	18	20	27
	52	50	63	27	38	51

As in 1985, significantly more nests occurred between Miles 59 and 127, within or just north of the Birds of Prey Area (BOPA) than in the remaining half of the intensive study area ($\chi^2 = 5.4$, $P < 0.05$). One stretch of line within the BOPA (Miles 113-119) contained a nesting pair in every mile (0.6 per km), more than 3 times the average density for the line.

Ravens and raptors sometimes occupied nests on adjacent towers. Red-tailed hawks nested within 370 m of occupied raven nests, and ferruginous hawks nested within 365 m of occupied raven nests. Minimum distances between conspecific raptor pairs always exceeded 1.4 km. In 1986, we observed ravens nesting closer to conspecifics than in past years. Two pairs nested in adjacent towers (159/4 and 160/1), and other pairs nested within 2 towers of each other. All cases of ravens nesting in close proximity occurred in between Miles 150 and 160, a 16-km stretch of line that crosses the Snake River from western Idaho into eastern Oregon.

Nest Site Selection

Raptors and ravens nested in all tower types on the line, but the frequency with which the tower types were used differed significantly from the frequency with which tower types were available ($G = 14.17$; $P < 0.001$). Although A towers (Fig. 2) were the most commonly used towers, they were by far the most common tower type available. Only 6% of the A towers were used in 1986, and 10 of the 69 breeding pairs that nested on A towers nested on platforms and not on the tower latticework. In contrast, raptors and ravens nested on 33% of the available T towers, 33% of the E towers, 14% of the C towers, and 12% of the F towers. Only the B towers had a lower rate of use (4%) than the A towers. The sturdier and more extensive latticework on the less common T and E towers (Fig. 2) may provide more suitable nesting substrate and therefore account for the raptor and ravens' apparent preferences for them.

Red-tailed hawks used more positions on the tower for nesting than the other 3 species (Fig. 3). Ravens appeared to be the least versatile in nest site selection, nesting in the x position 96% of the time. The "x" position of the tower (Fig. 3) was the most frequently used position on the towers, used by 68 of 71 breeding ravens, 13 of 25 red-tailed hawks, and 3 of 8 ferruginous hawks. An eagle pair nested in the x-position of Tower 119/3 where PP&L personnel had installed a plywood platform in the x-south position.

More than 60% of the golden eagle and ferruginous hawk pairs nested on the specially designed artificial platforms that were installed at the time of line construction. A preference by hawks and eagles for the platforms is apparent when one considers that only 2% of the towers on the line contain platforms. Ten of 37 available platforms were used by breeding raptors in 1986 (2 by golden eagles, 5 by ferruginous hawks, and 3 by red-tailed hawks). Nine of the 10 platforms used in 1986 had been used by raptors in previous years. Seven of the 10 were used for nesting in 1985. One pair of ferruginous hawks used a platform on Tower 96/3 that

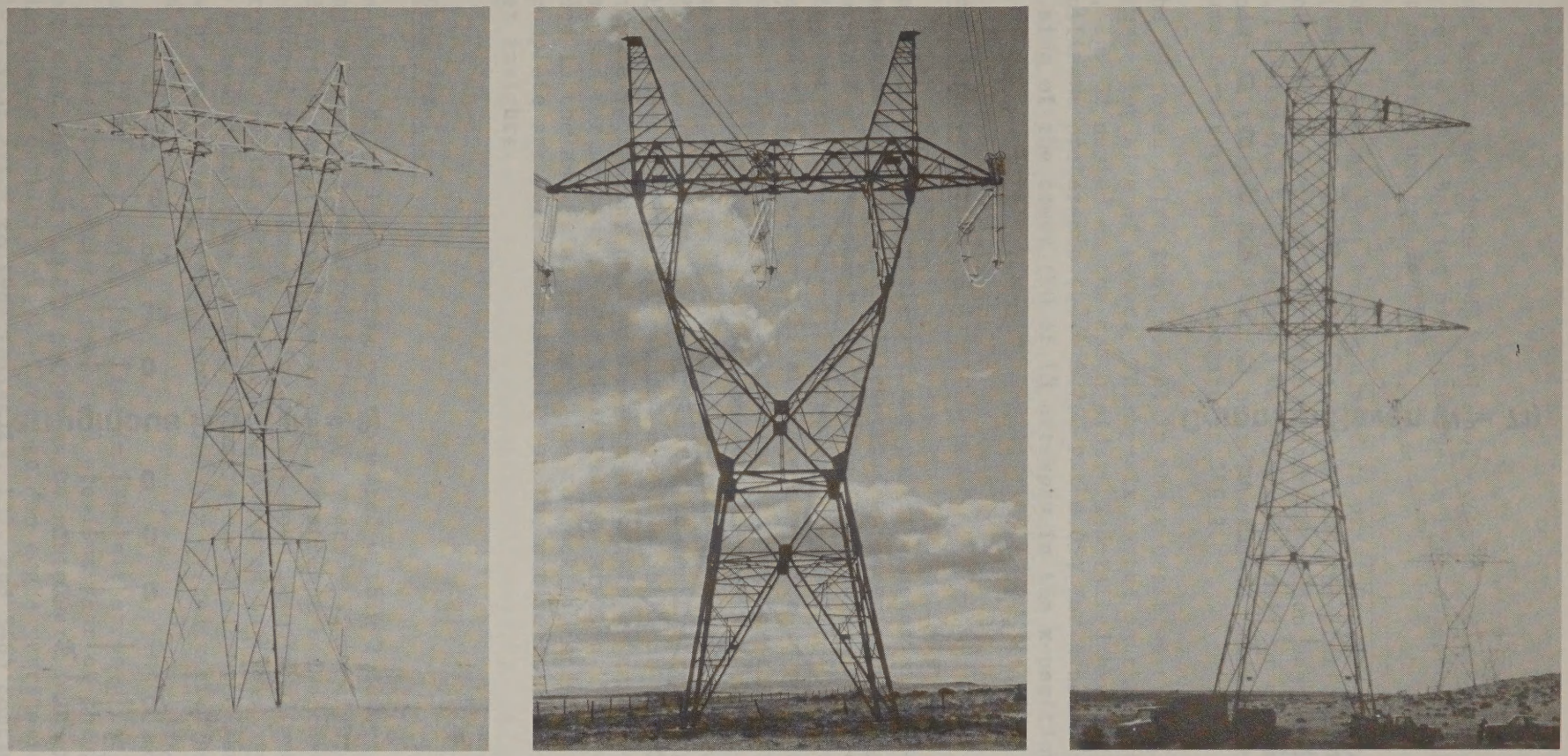


Fig. 2. Tower types used by raptors and ravens for nesting. The "E" (center) and "T" (right) towers were preferred over the more common "A" towers (left) apparently because of their sturdier and more extensive latticework.

Golden Eagle (N=3)

C —— 0

X —— 33

P —— 67

W —— 0

B —— 0

D —— 0

E —— 0

Ferruginous Hawk (N = 8)

C —— 0

X —— 38

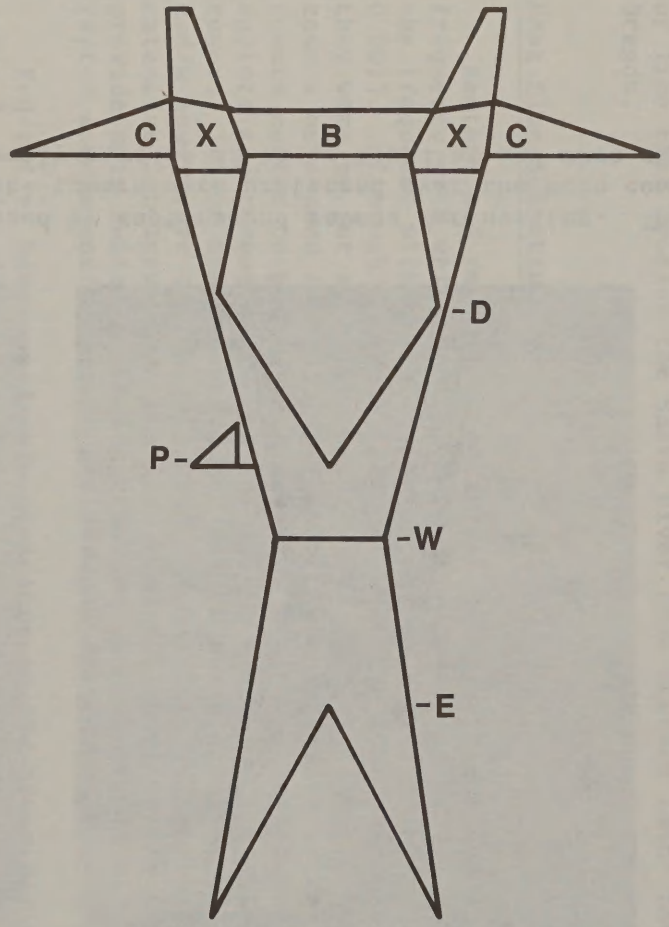
P —— 62

W —— 0

B —— 0

D —— 0

E —— 0



Red-tailed Hawk (N = 25)

C —— 8

X —— 52

P —— 12

W —— 20

B —— 0

D —— 4

E —— 4

Common Raven (N = 71)

C —— 0

X —— 96

P —— 0

W —— 1

B —— 0

D —— 3

E —— 0

Fig. 3 Percent of raptor and raven breeding attempts in relation to tower position for the PP&L Malin to Midpoint 500kV transmission line, 1986. Sample sizes are shown in parentheses. Summaries do not include "T" towers.

had not been used since 1983, and another used one at Tower 113/3 that had never been used. Baiting of platforms in 1985 appeared to have little effect on platform use in 1986.

Four platforms that had been used in previous years were not used in 1986 (Towers 49/3, 81/4, 311/5, and 346/2). The platform at Tower 346/2 has not been used since 1981 when a pair of golden eagles raised 1 young in it. During our 1986 survey, we observed a pair of eagles tending young in a nest on the BPA 800 kV line near Tower 346. This nest might be in the same territory as that containing 346/2.

The 68 raven pairs that nested in the x-position showed no significant preference for side of tower. Thirty-six nested on the north end of the tower, and 32 nested on the south side. Red-tailed hawks, however, showed a significant preference ($\chi^2 = 3.76$, $P < 0.05$) for x nests on the south side of the tower (10 of 13 attempts in the x-position).

Habitat Characteristics

In 1986, there was a significant positive association between nests and rangeland habitats. Significantly fewer nesting than random towers had farmland within a tower span radius ($P < 0.05$). This pattern emerged over the entire line ($\chi^2 = 6.48$) for both raptors ($\chi^2 = 5.50$) and ravens ($\chi^2 = 3.95$). Other habitat characteristics we measured provided little insight into factors influencing nesting tower selection. Over the entire line, the frequency of topographic situations were similar for random and nest towers ($P < 0.05$). Within the intensive area, there was no difference ($P < 0.05$) between nesting towers and random towers in the amounts of shrubs or grassland; the amount of habitat interspersion or topographic variation; or the presence of cliffs or agriculture. Fourteen towers used for nesting within the intensive area in 1986 were not included in the analysis, however, due to lack of funds and personnel. A more complete analysis for all nests on the entire line should provide further insights.

Nest Site Fidelity

In 1986, 85 of 114 nesting pairs nested within 2 towers of where a nesting attempt had occurred in earlier years. Sixty-eight of these pairs nested on the same tower where an earlier attempt had occurred, and 61 of these nested in the same position on the tower. Only 42 nesting territories used in earlier years were not used in 1986. By 1986, at least 45 towers had been used for 3 years or more by the same species; 4 towers by eagles, 4 by ferruginous hawks, 6 by red-tailed hawks, and 31 by common ravens.

Raptors that nested on the line in 1986 either used the exact same tower and position that was used in a previous year or they established an entirely new territory. All golden eagle nests were in the same tower and position as in earlier years. Three golden eagle territories, each used in only 1 year prior to 1984 (Miles 55, 132, and 346) continued to be

unoccupied in 1986. Seventeen red-tailed hawk nests were located in the same position as in earlier years. Eleven red-tailed hawk nests were in new territories, and 8 territories used in previous years were vacant. Ferruginous hawks built nests in 3 new territories, 8 traditional territories were unoccupied, and 5 pairs nested in positions that were used in past years.

Fifty-nine of 74 raven pairs nested within 2 towers of where a raven nesting attempt occurred in a previous year. More than half (42) of the ravens nesting on the line in 1986 nested in a tower that was used in earlier years. Thirty-five of these pairs used a position on the tower that was used in earlier years, and 28 of these used the same position used in 1985. Fifteen raven nesting attempts were in territories that had never been used previously.

Nest site fidelity of ravens did not appear to be related to nesting success in the previous year. All 3 raven territories in the intensive area that were unsuccessful in 1985 were re-occupied in 1986. In all 3 cases, ravens used the same tower where an unsuccessful attempt had occurred the previous year, and in 2 cases, they used the same position. In contrast, of 34 territories that successfully produced raven young in 1985, only 32 were re-occupied in 1986; only 28 nests were in the same tower; and only 24 were in the same position. Sample sizes are small, but they support the findings of earlier years.

Raven nest site fidelity appeared to be stronger in the intensive area than in the extensive area. Eighty-three percent of raven nesting attempts in the intensive area were in territories that had been used in previous years, whereas only 74% of raven nesting attempts in the extensive area were in traditional territories. Seventy percent of intensive area nests were in the same tower as in earlier years, compared with only 34% tower re-use in the extensive area. This pattern did not appear to be an artifact of differences in numbers of pairs in the 2 areas. In the intensive area, 95% of territories used in 1985 were re-used in 1986, whereas only 75% of the 1985 territories in the extensive area were re-used. Of the 23 traditional raven territories on the line that were not used in 1986, 16 (69%) were in the extensive area which has only 44% of the total number of traditional raven territories.

Nest Persistence

One factor that may influence site fidelity is whether or not nests remain intact from one nesting season to the next. Our survey on 28 October indicated that approximately half of the nests on the line remained intact 4 months after the breeding season. Sixty-one of the 114 nests used in 1986 (54%) were in moderate or good condition during the October survey, while 53 (46%) were completely gone or in serious disrepair.

Two factors, species and nest position, seemed to be associated with nest persistence. Nests that were successful had the same rate of loss/deterioration as unsuccessful nests ($\chi^2 = 0.33$; $P > 0.05$). All

nests in artificial platforms were in good or moderate condition, compared with only 52% of nests in the x-position that were intact. Nests below the bridge suffered the highest loss rate: 67% of nests in the waist and "D" positions were completely gone by the 28 October survey.

Golden eagle and ferruginous hawk nests had the highest persistence rate (100% and 62% in good or moderate condition for the 2 species respectively). This finding is no doubt related to the use of artificial platforms by these species. In general, buteo nests were highly unstable. All 3 ferruginous hawk nests that were not in platforms had disappeared by October. Only 7 of 25 (28%) red-tailed hawk nests that were not in platforms were in good to moderate condition by October. Overall, 64% of all red-tailed hawk nests and 43% of raven nests had disappeared or were in serious disrepair 4 months after the breeding season.

Nesting Success and Productivity

All ferruginous hawk and raven pairs associated with nests on the power line within the intensive survey area laid eggs in 1986, but only 3 of 4 eagle pairs (75%) laid eggs. Breeding could not be confirmed at 1 unsuccessful red-tailed hawk nest in the intensive area. Two of three breeding eagle pairs were successful, and 75% of the ferruginous hawk, 33% of the red-tailed hawk, and 81% of the raven pairs produced young that fledged. Cause of nesting failure could be determined at only 2 towers where the nests had been blown out by wind. Blow-outs were also responsible for 2 nest failures in the extensive area. Number of young fledged per pair in the intensive area averaged 1.00 for eagles, 0.66 for red-tailed hawks, 1.50 for ferruginous hawks, and 2.83 for common ravens (Table 3).

Reproductive rates of golden eagles nesting on the line were much higher than those of eagles nesting on nearby natural substrate. Fifty eagle pairs in the canyon adjacent to the power line fledged only 0.32 young per pair. Both percent breeding and percent of breeding attempts successful were higher on the line than on the cliffs (75% vs. 56% and 67% vs. 43% respectively).

Ferruginous hawk pairs nesting on the 500 kV line also were more successful than pairs in the surrounding area Seventy-five percent of ferruginous hawk nesting attempts on the 500 kV line were successful compared with a 50% success rate for attempts on other substrate. Number of young per successful nest, however, was lower on the 500 kV line than in the surrounding area (2.00 compared with 3.25).

The 2 eagle young produced on Tower 119/3 comprised 25% of the total number of golden eagle young produced in the BOPA in 1986. This was the first year that young successfully fledged from Tower 119/3. Nesting attempts in 1983 and 1984 were unsuccessful, and the resident eagle pair did not breed in 1985. In 1984, a nestling eagle died when its nest in the x-south position was blown from the tower during a severe windstorm. This incident prompted PP&L personnel to install a plywood platform where

Table 3. Nesting success and productivity of raptors and ravens on the PP&L Malin to Midpoint 500 kV transmission line (intensive survey stretch), 1986.

	No. of Pairs	% Breeding	% of Breeding Attempts Successful	No. Fledged Per Succ. Attempt	No. Fledged Per Pair
Golden Eagle	4	75%	67%	2.0	1.00
Ferruginous Hawk	8	100%	75%	2.0	1.50
Red-tailed Hawk	4	100%	33%	2.0	0.66
Common Raven	47	100%	81%*	3.5	2.83

* based on the Mayfield (1961) estimate of nesting success

the nest had been to provide additional stability for future eagle nests. With the additional support, the 1986 nest survived the nesting season and was still in good shape in October.

DISCUSSION

After a year of what appeared to be a plateau in colonization rates, the number of raptors and ravens nesting on the line increased significantly in 1986. One explanation for the sharp increase in the number of nesting pairs on the line in 1986 would be that the offspring of transmission line nesters have started to establish their own nesting territories. Red-tailed hawks, for example, usually do not breed until they are at least 2 years old (Newton 1979). The first year that more than 10 red-tailed hawks nested on the line was in 1984 (Table 1). Therefore, 1986 would have been the first year that significant numbers of offspring from those nesting attempts were old enough to breed. Average age at first breeding in ravens is not well documented. The 1986 increase, 3 years after a significant number of ravens first nested on the line, could be consistent with the explanation above.

Earlier (Kochert et al. 1984), we presented 2 hypotheses to account for higher nesting densities on the Idaho portion of the line. The first was that habitat differences may be associated with differences in prey density and the quality of foraging habitat. The second was that in Idaho, the line is closer to established nesting populations that may be the source of birds using the line.

Data from 1986 indicate that agriculture may be 1 component that influences nest distribution. Otherwise, habitat conditions were similar at used and unused towers. Significant preferences for certain tower types suggests that characteristics of nesting substrate may be more critical than habitat characteristics in determining whether a particular tower will be used for nesting.

Future, more comprehensive habitat analyses will clarify the patterns we observed in 1986. In addition, more information is needed on philopatric tendencies of raptors and ravens to determine more precisely the factors influencing colonization rates and patterns of nesting density.

The 1986 nesting season provided evidence that inexpensive alterations to tower structures where bird activity has been noted can enhance the nesting success of raptors, particularly golden eagles. Further experimentation with such structures should provide useful information.

PLANS FOR NEXT YEAR

Surveys of nesting raptors and ravens on the line will continue using the same procedures as in 1986. In addition, we will continue to gather comparative data on reproduction of golden eagles and ferruginous hawks nesting in the canyon. Habitat surrounding nesting and random towers in

the extensive area will be characterized as maps and photos become available. We will also attempt to characterize contamination levels at used and unused towers, and we will expand our investigation of nest persistence.

ACKNOWLEDGMENTS

This report is dedicated to the memory of of the late Vern Haney who was the pilot on many of our surveys in 1986 and whose skill made successful completion of the surveys possible. S. Sandmeyer also piloted several survey flights for us. We thank K. Engel for assistance with the 28 October helicopter survey. L. Young and S. Wilder provided logistical support that made the study possible. K. Engel and A. Brody gathered data that helped to interpret nest fates.

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TITLE: Implications of Communal Roosting by Common Ravens to Operation and Maintenance of the Malin to Midpoint 500 kV Transmission Line.

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COOPERATOR: Pacific Power and Light Company

OBJECTIVES:

1. Determine the extent of communal roosting by common ravens on the Midpoint to Malin 500 kV transmission line.
2. Evaluate ravens' use of transmission towers.
3. Evaluate different means of controlling fecal contamination of insulators.
4. Develop the ability to predict potential locations of raven communal roosts.

ANNUAL SUMMARY

Large concentrations of common ravens (Corvus corax) have roosted on towers of Pacific Power and Light Co.'s (PP&L) Malin to Midpoint 500 kV transmission line since at least 1982. Concern has been raised that accumulation of large quantities of raven feces on insulators of roost towers may be contributing to poor operational performance. Research to determine implications of raven communal roosting to operation and maintenance of the line continued during 1986.

Work was conducted between miles 83 and 160 of the transmission line. This segment was surveyed once a month to locate occupied roosts, and all occupied roosts were simultaneously observed once a month to estimate the roosting population. Weekly observations were made at the Wilson Creek Roost (miles 131-132) to evaluate responses of ravens to shields and pegging installed there during 1985. Contamination was estimated monthly at 4 major roosts on the line; contaminated insulator bells were ranked according to a visual scale. To obtain information needed to predict potential roost locations, ravens associated with roosts were captured and equipped with radio transmitters. Transmitter-equipped ravens were observed continuously from the time they left the roost in the morning until they settled into their roosts for the night. Locations were recorded, and a detailed record of habitat use was kept. To examine relationships among roosting, habitat use, and diet of ravens, pellets regurgitated by ravens were collected beneath roost towers and analyzed to determine diet composition.

Ravens used 7 roosts on the line from November 1985 to October 1986. Five of these roosts were also occupied in 1984 and 1985. The other 2 were new roosts occupied for less than 1 mo. Most roosts were used predominantly

during spring and summer, although the Marsing Southwest Roost (miles 153-156) was used most heavily during autumn and winter. The Initial Point Roost (miles 106-113) remained the largest roost on the line. A peak count of 1,226 ravens was recorded there during August. A new high of 540 ravens was recorded at the Swan Falls Road Roost (miles 114-116) during March. The total number of ravens roosting on the 500 kV line peaked at 1,799 during August.

Overall contamination levels for the line decreased gradually from late winter through late spring, rose sharply during summer, then started to decline again during autumn. Peak contamination levels at the Marsing Southwest Roost were recorded in late winter. Towers at the Marsing Southwest Roost had the highest contamination levels throughout the year.

Ravens reoccupied the Wilson Creek Roost during late March and used the roost until mid-October. Ravens' distribution among tower sections approximated that observed in spring 1985, before shields and pegging were installed. Shields and pegging continued to effectively prevent insulator contamination, although many strips of pegging fell from towers as the nylon bands used to secure them to the tower lattice deteriorated.

Sixteen ravens were captured and equipped with radio transmitters. Thirteen ravens were captured at feeding areas, using leghold traps. Success rates were highest in autumn and winter and lowest during summer. The other 3 ravens were captured as fledglings near their nests. Over 1,400 locations were recorded for transmitter-equipped ravens; these ravens were observed for over 700 hours. Movements, habitat use, and food habits data have not yet been analyzed; these data will be presented in the final study report.

INTRODUCTION

Large concentrations of common ravens have roosted on towers of PP&L's Malin to Midpoint 500 kV transmission line since at least 1982 (Engel and Young 1985). In 1984, a peak count of 2,103 ravens was recorded at the Initial Point Roost, within the Snake River Birds of Prey Area (Engel and Young 1985). This is by far the largest reported roosting aggregation of this species (Knight and Call 1980, Allen and Young 1982). Groups of up to 933 ravens have roosted at 7 other locations on the line (Steenhof 1983, Engel and Young 1985, Young and Engel 1986).

Accumulation of large quantities of raven feces on insulators, etched insulators at roost towers, and a higher than anticipated fault rate for the line prompted concern that fecal contamination may be contributing to poor operational performance. In response to these concerns, cooperative research between PP&L and the Bureau of Land Management's (BLM) Snake River Birds of Prey Research Project was initiated in 1983. PP&L's goals are to determine the most effective approach for managing contamination on the Midpoint to Malin 500 kV line, and determine how routing and design considerations can prevent similar problems on future transmission lines. BLM's goals are to obtain data needed to make informed decisions regarding routing of transmission lines across public lands and reduce potential

wildlife/transmission line conflicts. Specific objectives of the study are to determine the extent of raven roosting on the transmission line, evaluate ravens' use of towers, evaluate different means of controlling fecal contamination of insulators, and develop the ability to predict potential roost locations. Principal objectives of the 1986 field season were to evaluate devices designed to prevent insulator contamination, and acquire information needed to define potential roost locations.

STUDY AREA

Work was conducted on the western Snake River plain, Idaho - Oregon, between miles 83 and 160 of the transmission line (Fig. 1). This segment of the line encompasses 6 of the 8 communal roosts that were located during 1983 and 1984 (Engel and Young 1985). The area is dominated by shrubsteppe vegetation (West 1983) and agriculture. Annual precipitation averages 20 cm (U.S. Dep. Inter. 1979), and most precipitation falls from late autumn to early spring. Summers are hot and dry. At the east end of the study area, the Snake River runs through a steep, narrow canyon, up to 250 m below the plain. The canyon diminishes as the river flows west, and at the west end of the study area, the river runs through flat to rolling terrain with scattered smaller cliffs and bluffs. In this area, the plain rises to the south to the Owyhee Mountains. The proportion of the plain that has been converted to agriculture generally increases from east to west.

METHODS

Surveys

To locate occupied roosts, miles 83-160 were surveyed once a month. Surveys were conducted by an observer driving maintenance roads adjacent to the line. Using a 15-60X spotting scope, the observer examined the insulators of each tower for accumulated feces. A tower was considered a potential roost tower if substantial contamination not associated with a nest was noted. Potential roost towers were observed within 2 days, in the evening, to confirm use. Reoccupancy of roosts used in previous years was indicated by increased contamination, and fresh pellets and feathers beneath the towers.

Coordinated Roost Watches

To monitor the total number of ravens roosting on the transmission line, all occupied roosts were simultaneously observed once a month. Observations were made by an observer in a vehicle parked at a good vantage point at least 400 m from the nearest roost tower. Both 15-60X and 20-45X spotting scopes and a 50-130X Questar telescope (Questar Corp., New Hope, Pa.) were used. The number of ravens perched on each roost tower was recorded every 10 min, from 10 min before sunset until it was too dark to count accurately (usually 40 min after sunset). The highest total count recorded during a 10 min interval was considered to represent the number of ravens using a roost.

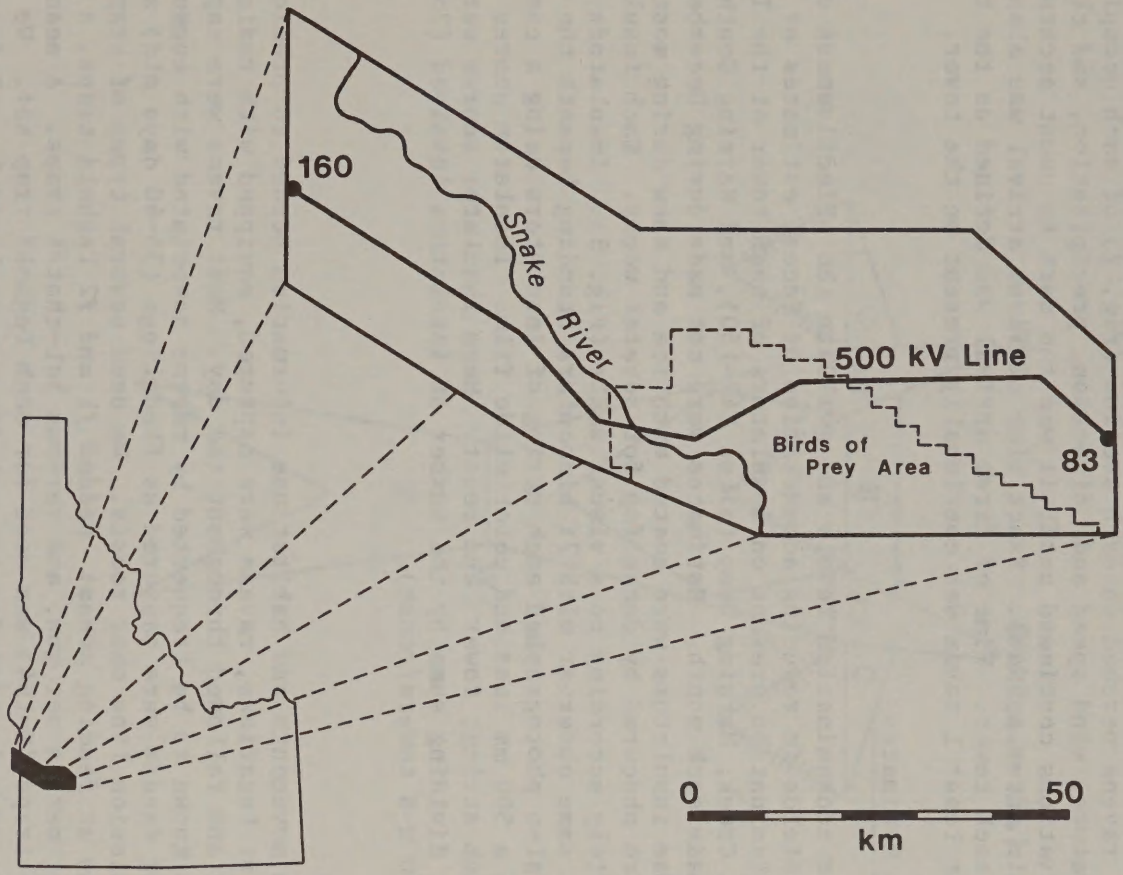


Fig. 1. Study area, southwestern Idaho - southeastern Oregon.

Weekly Roost Watches at Wilson Creek

In June 1985, fiberglass shields and wooden pegging designed to prevent insulator contamination were installed on towers at and adjacent to the Wilson Creek Roost (Young and Engel 1986). The roost was abandoned for the year during early August. To determine reoccupancy of the roost and evaluate ravens' responses to shields and pegging, the Wilson Creek Roost was observed each Thursday evening, starting in early March. Observations were made by an observer parked at least 400 m from the nearest roost tower. Every 10 min, starting 1 hour before sunset, the observer recorded the number of ravens perched on each section (Fig. 2) of each occupied tower, temperature, wind speed and direction, precipitation, and cloud cover. Observations continued until it was too dark to count accurately (usually 40 min after sunset). Exact time of first arrival was also recorded for each tower. Time of first arrival was defined as the time after which at least 1 raven was continually present on the tower.

Contamination Estimates

To monitor contamination levels and evaluate the effectiveness of pegging and shields in reducing accumulation of feces, estimates of the amount of contamination present on insulators of each tower at the Initial Point, Wilson Creek, Marsing Dump (miles 147-150), and Marsing Southwest roosts were made each month. Estimates were not made during December and January because insulators were coated with ice and snow during most of this period and were obscured by dense fog for several weeks. Each insulator was ranked separately according to a visual scale (Fig. 3). Insulators were ranked by the same observer with 7X binoculars standing beneath the tower. The observer also photographed each string of insulators using a camera equipped with a 500 mm lens and color slide film. Insulator scores were summed for each string, tower, and roost. Mean insulator scores were determined by dividing sums by the number of insulators involved (25/string, 150/tower, 150 x N towers/roost).

Telemetry

To obtain movements and habitat use information needed to predict potential roost locations, ravens were captured, equipped with radio transmitters, and followed throughout the day. Most ravens were captured at feeding areas known to be frequented by ravens associated with communal roosts. Other ravens were captured as fledglings (35-40 days old) at nests on the transmission line near roosts. We used several types of traps to capture ravens at feeding areas: padded *f*1 and *f*2 leghold traps, a drop-in trap, a rocket net, a net gun, and various bal-chatri traps. A mean of 7.3 $\pm$ 3.1 leghold traps (N=164) was used for each leghold trap set. We always pre-baited the drop-in trap for several days, and placed 1 or 2 decoy ravens in the trap after pre-baiting. Several types of bait were employed, predominantly carrion. Rabbits, pheasants, mice, and whole or quartered calves were the most commonly used forms of carrion. Grain and eggs were occasionally used as bait. In assessing trapping effort, we considered traps set before light to be open 30 min before sunrise, and all traps to be closed at sunset. With leghold traps, 1 trap hour refers to a set (group) of traps open for 1 hour. With the drop-in trap, we did not include

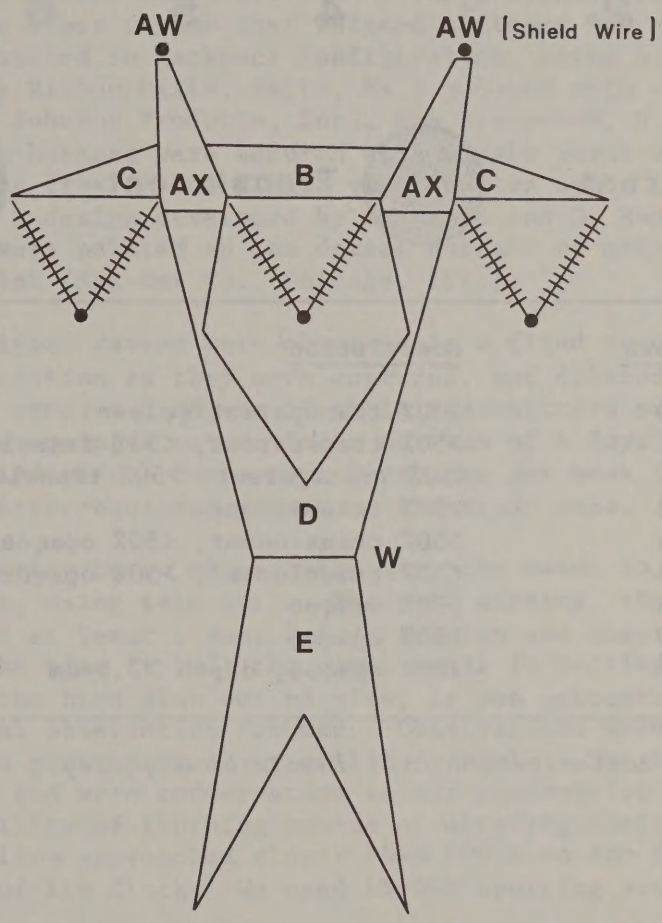
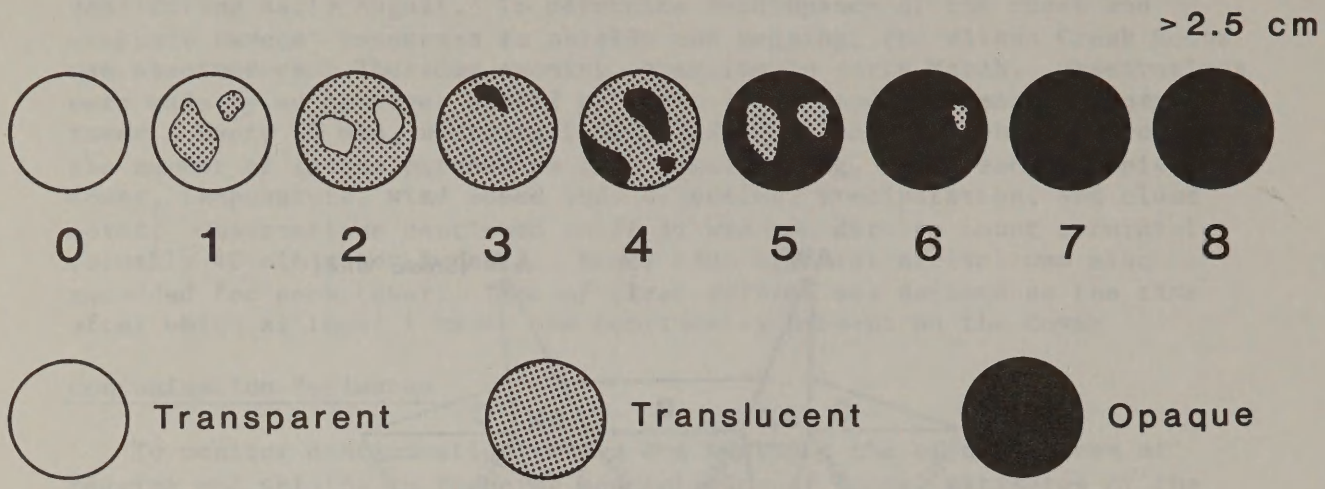


Fig. 2. Tower sections identified for data collection.

Fig. 3. Visual categories used to rank contaminated insulators.



Score	Description[1]
0	100% transparent (clean)
1	>50% transparent, <50% translucent
2	<50% transparent, >50% translucent
3	>90% translucent
4	>50% translucent, <50% opaque
5	<50% translucent, >50% opaque
6	>90% opaque
7	100% opaque
8	100% opaque, depth >2.5 cm

[1]Distribution of contamination over insulator may vary.

pre-baiting days in capture effort calculations. Only days after pre-baiting when decoy ravens were in the trap were included. Fledgling ravens were captured by hand.

We estimated age of captured ravens according to mouth color (Kerttu 1973). Ravens with predominantly pink palates were considered juveniles (HY), those with gray or heavily mottled palates were considered subadults (AHY), and those with black palates were considered adults (ASY).

Each captured raven was equipped with a radio transmitter, wing markers, and a U.S. Fish and Wildlife Service size 6 lock-on aluminum band. We used 2 types of transmitters: Telonics Configuration 1 (Telonics, Inc., Mesa, Ariz.) for fledgling ravens and other ravens that weighed less than 950 g, and Telonics RB5 for other ravens that weighed at least 950 g. All transmitters were mounted in backpack configuration, using 6.4 mm tubular teflon ribbon (Bally Ribbon Mills, Bally, Pa.) secured with waxed dental floss (Johnson and Johnson Products, Inc., New Brunswick, N.J.). All 4 ends of the backpack harness were secured at a single point on the breast. Wing markers were cut from yellow TXN-18 vinyl-coated nylon (Cooley, Inc., Anaheim, Calif.) in a design developed by S. Platt and D. Runde (pers. commun.). Numbers were painted on the dorsal surface of markers with black gloss vinyl screen ink (Naz-Dar Co., Chicago, Ill.).

Transmitter-equipped ravens were observed in a fixed sequence. Ravens were added to the rotation as they were captured, and deleted from it if they left the study area or died, or if their transmitters expired. We observed transmitter-equipped ravens for a maximum of 4 days per week; we did not observe an individual raven more than once per week if there were fewer than 4 transmitter-equipped ravens in the study area.

On the evening prior to an observation day, the raven to be tracked was located at its roost, using telemetry. The next morning, the observer arrived at the roost at least 1 hour before sunrise and observed the raven continuously from the time it left the roost until it settled into its roost for the night. If the bird flew out of view, it was relocated using telemetry, and visual observation resumed. Observations were made by a single observer in a pick-up truck or utility vehicle. We almost always used existing roads and were conservative in our observation distances to minimize the possibility of flushing ravens or altering their behavior. In open country, we seldom approached closer than 400 m to the focal raven or the nearest member of its flock. We used 15-60X spotting scopes and various binoculars.

Locations were plotted on 1:24,000 topographic quadrangles in the field. To qualify a new location, a raven had to move at least 100 m. This stipulation was adopted to avoid collecting a meaninglessly high number of locations. All locations were confirmed visually; approximate locations were not recorded. We did not employ triangulation techniques due to the high degree of triangulation error that often occurs when making observations (bearings) over distances of several hundred meters or more or in rough terrain (Springer 1979, Hupp and Ratti 1983, Crenshaw 1985) and the high degree of interspersion among habitat types in the study area. Only locations where ravens perched or landed on the ground were recorded. We

did not record locations of flying ravens because we felt these were ambiguous with respect to habitat use. Time spent at each location and habitat type were recorded on a field form. Each time a raven shifted to a different habitat, a new entry was made. Shifts in habitat often occurred without a corresponding shift in location: ravens commonly shifted between habitats without moving 100 m.

Pellet Collections

To examine relationships among roosting, habitat use, and diet of ravens, we collected pellets regurgitated by ravens beneath roost towers. Pellets were collected through April; combined with collections made during 1985 this provided a continuous year of food habits data. Pellets were collected at the Initial Point, Swan Falls Road, Wilson Creek, Marsing Dump, and Marsing Southwest roosts. At each roost, a transect was established beneath a tower that was being used by a large number of ravens. All pellets within 50 cm of a transect were removed weekly, and a random sample of 5 pellets was selected and stored for analysis. Transects were shifted as ravens shifted among towers throughout the season.

In the laboratory, pellets were weighed and measured, and composition was determined. Food remains were identified using taxonomic keys and by comparison to reference specimens. For animal remains, the minimum number of individuals per taxon was determined (Mollhagen et al. 1972). Vertebrate remains were identified to species, and invertebrate remains were identified to order. Amounts of different types of plant material were weighed to the nearest 0.01 g using an analytical balance.

RESULTS

Use of Roosts

Ravens used 7 roosts on the transmission line between November 1985 and October 1986 (Fig. 4). Five of the 7 were roosts that had been occupied during previous years. The Pleasant Valley Road Roost (miles 101-103) was not occupied during this period. This roost was the major roost on the transmission line during 1983 (Steenhof 1984), was occupied by up to 144 ravens from June to August 1984 (Engel and Young 1985), but was not occupied during 1985 (Young and Engel 1986).

The Alkali Creek Roost (mile 160), 1 of the 2 new roosts, was occupied only during November 1985; 701 ravens were counted there during the November coordinated watch. It is likely that these ravens were associated with the Marsing Southwest Roost (miles 153-156) during most of the month. No ravens used the Marsing Southwest Roost on the evening 701 birds were counted at the Alkali Creek Roost, although an average of 838 ravens had roosted at the Marsing Southwest Roost during October (Young and Engel 1986), and observations made while tracking transmitter-equipped ravens revealed that the Marsing Southwest Roost was used by several hundred ravens on some nights during November.

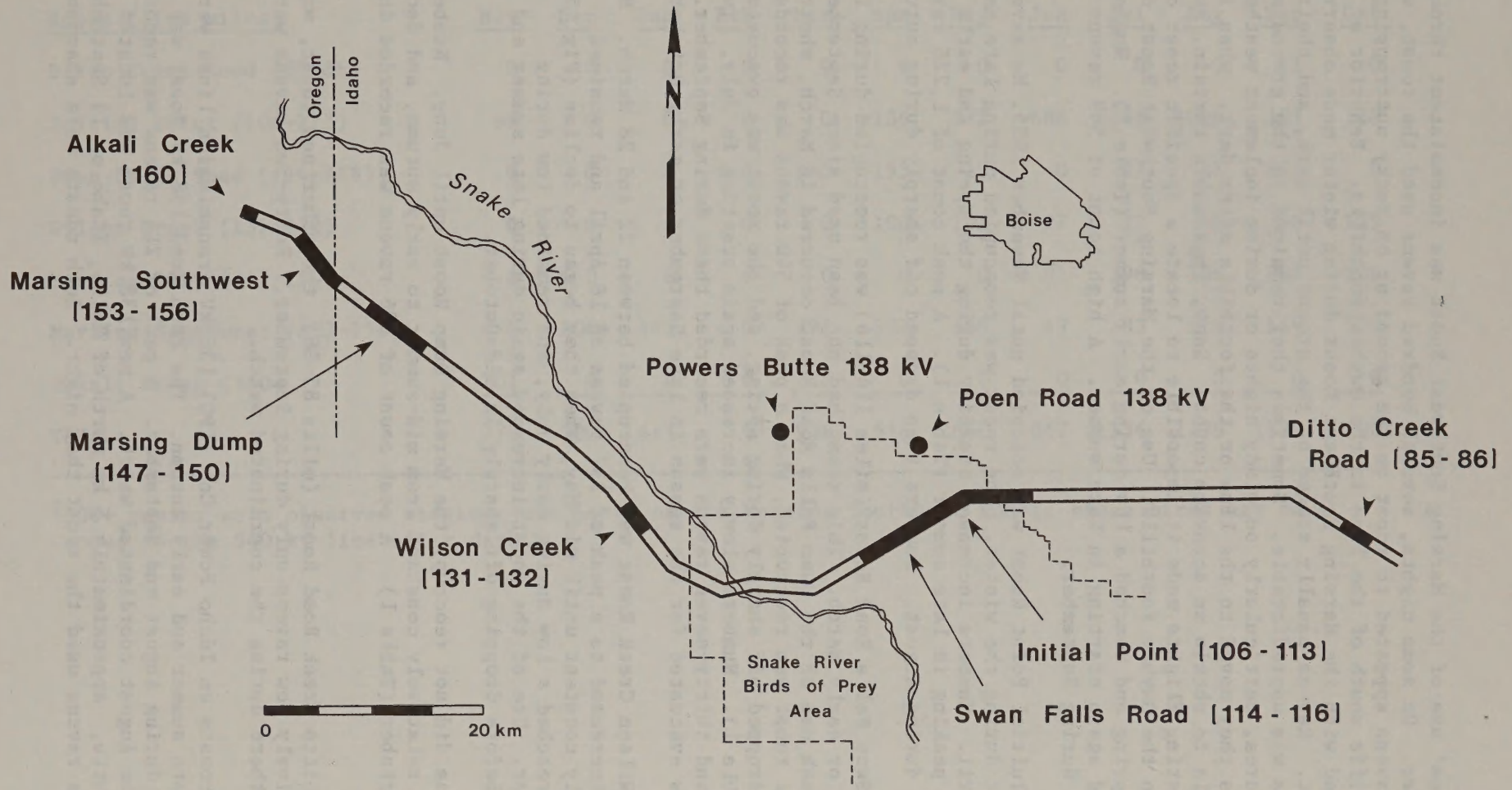


Fig. 4. Raven communal roosts located in the study area, November 1985 - October 1986.

Ravens' use of the Marsing Southwest Roost was inconsistent throughout the winter. On some nights, several hundred ravens used the roost, while on others ravens appeared to roost on the ground or on rocky outcroppings and small cliffs south of the line in the Owyhee foothills. Behavior of ravens associated with the Marsing Southwest Roost during winter made observations difficult. Ravens usually staged on the ground until dark, and their choice of roosts was unpredictable. Sometimes they remained on the ground at the staging area, particularly on windy nights or during inclement weather, and sometimes they moved to the line or the foothills after dark, when it was impossible to obtain an accurate count. Snow, impassable terrain, and after dark roosting flights made it impossible to locate a specific roost or roosts in the Owyhee foothills. Use of the Marsing Southwest Roost declined during spring and reached a low during early summer (Table 1). Numbers increased again starting in late summer. A high count of 549 ravens was recorded during September.

The Initial Point Roost was occupied until November 1985. No ravens used the roost during the winter. The roost was reoccupied during late March or early April. Numbers increased steadily during the spring and early summer, peaking in late summer (Table 1). A peak count of 1,226 ravens was recorded during August. Numbers then dropped off sharply during autumn.

The Swan Falls Road Roost (miles 114-116) was reoccupied during late February or early March. This roost had not been used since September 1985. Peak use of the Swan Falls Road Roost occurred in March, shortly after the roost was reoccupied, when a peak of 540 ravens was recorded. Numbers dropped off sharply during spring, and the roost was evacuated by June (Table 1). Numbers slowly increased again starting in July. Two hundred and thirty-seven ravens were recorded there during September. The roost was evacuated for the season in late September or early October.

The Wilson Creek Roost was reoccupied between 22 and 28 March. Numbers quickly increased to a peak of 137 ravens on 18 April and remained relatively constant until mid-May, when they began to decline (Fig. 5). Numbers reached a low during early July, and remained low during mid-summer. Use of the roost increased again during late summer and early autumn, before dropping off sharply in mid-October.

Ravens did not reoccupy the Marsing Dump Roost until June. Numbers remained relatively constant from mid-summer to early autumn, and declined during October (Table 1). A peak count of 306 ravens was recorded during August.

The Ditto Creek Road Roost (miles 85-86), the other new roost, was used by relatively few ravens only during September. Forty-two ravens were counted there during the coordinated watch.

Two roosts on Idaho Power Co. (IPC) 138 kV transmission lines were used during late summer and early autumn. The Poen Road 138 kV Roost was occupied during August and September. A peak of 214 ravens was recorded during the August coordinated watch. A new 138 kV roost was located near Powers Butte, approximately 5 km north of Melba, Idaho on 14 September. Sixty-one ravens used the roost that night. Both roosts were abandoned by

Table 1. Numbers of ravens counted at transmission line roosts in the study area during coordinated roost watches, November 1985 - October 1986.

Roost (line miles)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Ditto Creek Road (85-86)	0	0	0	0	0	0	0	0	0	0	42	0
Initial Point (106-113)	69	0	0	0	0	136	371	686	1145	1226	353	188
Swan Falls Road (114-116)	0	0	0	0	540	193	19	0	17	41	237	0
Wilson Creek (131-132)	0	0	0	0	0	100	102	27	13	48	66	125
Marsing Dump (147-150)	0	0	0	0	0	0	0	91	298	306	286	106
Marsing Southwest (153-156)	0	200+	441	0[1]	398	187	168	43	83	178	549	171
Alkali Creek (160)	701	0	0	0	0	0	0	0	0	0	0	0
TOTAL	770	200+	441	0[1]	938	616	660	847	1556	1779	1533	590

[1]300+ ravens were observed staging just north of the Marsing Southwest Roost; these birds may have moved to the 500 kV line after dark.

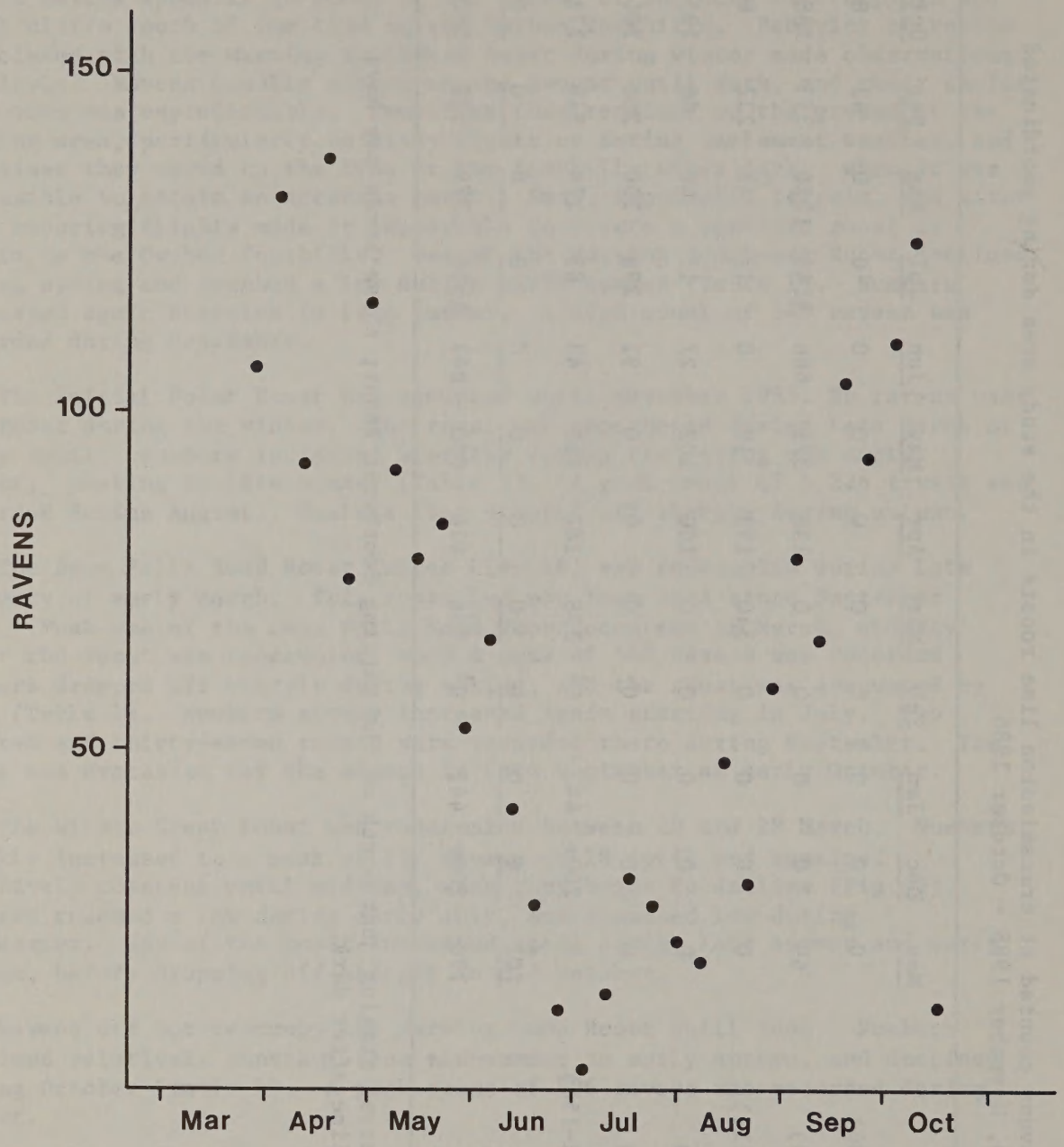


Fig. 5. Numbers of ravens using the Wilson Creek Roost (miles 131-132), March - October 1986.

mid-October. The Nicholson Road 138 kV Roost, used during late summer 1985, was not occupied this year. No ravens using the Swan Falls Road Roost roosted on the 138 kV line there.

Ravens' use of towers at 500 kV roosts was similar to 1985. Only 2 differences are noteworthy. Ravens at the Initial Point Roost used towers in mile 106 for the 1st time, and ravens using the Marsing Southwest Roost began using towers in mile 153 during autumn.

Total numbers of ravens roosting on the 500 kV line were highest during late summer and early autumn (Table 1); a peak of 1,799 ravens was recorded during August.

Contamination

Contamination levels at the Initial Point Roost dropped gradually from February through April, leveled off in May, and increased gradually during June (Table 2). Levels rose sharply during July and August when large numbers of ravens used the roost, and dropped off sharply during September and October as numbers of ravens decreased. Contamination levels at the Wilson Creek Roost remained low throughout the year, due to the protection afforded by pegging and shields. Levels at the Marsing Dump Roost remained relatively constant from February to June, then increased during mid-summer, after ravens occupied the roost. Levels at the Marsing Southwest Roost were highest in late winter, declined from spring through mid-summer, and increased again starting in late summer. Overall levels for the 500 kV line decreased gradually from late winter through late spring, rose sharply during the summer, and declined during autumn (Table 2). Peak contamination levels were recorded in late summer and early autumn.

Towers at the Marsing Southwest Roost showed the highest mean insulator scores throughout the year (Table 3). Only in August, when peak numbers of ravens occupied the Initial Point Roost, did the mean score for towers there equal that of towers at the Marsing Southwest Roost. Towers at the Wilson Creek Roost had the lowest mean insulator scores throughout the year, while towers at the Marsing Dump Roost had intermediate values. Trends in overall mean scores closely paralleled trends in overall contamination (Table 3). The number of towers at each roost with measurable contamination changed little throughout the year (Table 2).

Evaluation of Shields and Pegging

Ravens reoccupied the Wilson Creek Roost between 22 and 28 March. On 28 March, 106 ravens roosted on tower 131/5, the same tower that was used in 1985 after shields and pegging were installed. Almost all ($\geq$99%) ravens used towers 131/3, 131/4, 131/5, and 132/1 during 1986. These towers have traditionally comprised the roost. One to 5 ravens were occasionally observed on tower 131/2. These ravens were probably the pair and offspring associated with the nest on tower 131/1.

Numbers of ravens using the Wilson Creek Roost followed the same trend as in 1985, although numbers were lower than in 1985. Numbers quickly reached a spring peak, then declined to a low during mid-summer (Fig. 5).

Table 2. Contamination levels at 4 major roosts within the study area, February - October 1986. Values represent the cumulative score (thousands) of all towers at the roost.[1] Parenthetical values represent the number of towers with measurable contamination.[1]

Roost (line miles)	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Initial Point (106-113)	4.8	4.3	4.0	4.0	4.5	6.8	10.2	8.6	6.0
	(29)	(29)	(29)	(29)	(30)	(30)	(29)	(30)	(30)
Wilson Creek (131-132)	0.8	0.9	0.7	0.9	0.7	0.6	0.6	0.8	0.7
	(6)	(7)	(8)	(7)	(7)	(7)	(7)	(7)	(7)
Marsing Dump (147-150)	1.9	1.8	1.9	1.6	1.7	2.4	2.9	2.4	2.6
	(11)	(11)	(11)	(11)	(11)	(11)	(11)	(10)	(11)
Marsing Southwest (153-156)	2.6	2.2	1.6	1.4	1.4	1.6	2.1	2.1	2.1
	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)
TOTAL	10.1	9.2	8.2	7.9	8.3	11.4	15.8	13.9	11.4

[1]Values do not include towers that could not be scored. Some insulator scores were affected by insulator maintenance.

Table 3. Mean insulator scores for towers at 4 major roosts within the study area, February - October 1986. Parenthetical values represent the number of towers with measurable contamination.[1]

Roost (line miles)	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Initial Point (106-113)	1.1	1.0	0.9	1.0	1.0	1.5	2.3	1.9	1.3
	(29)	(29)	(29)	(29)	(30)	(30)	(29)	(30)	(30)
Wilson Creek (131-132)	0.9	0.9	0.6	0.8	0.7	0.5	0.6	0.8	0.6
	(6)	(7)	(8)	(7)	(7)	(7)	(7)	(7)	(7)
Marsing Dump (147-150)	1.2	1.1	1.1	1.0	1.0	1.5	1.8	1.6	1.6
	(11)	(11)	(11)	(11)	(11)	(11)	(11)	(10)	(11)
Marsing Southwest (153-156)	2.9	2.5	1.8	1.6	1.5	1.7	2.3	2.4	2.4
	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)
MEAN	1.3	1.2	1.1	1.0	1.1	1.4	2.0	1.7	1.4

[1]Values do not include towers that could not be scored. Some insulator scores were affected by insulator maintenance.

Starting in late summer, numbers increased to a 2nd peak before dropping off rapidly as the roost was evacuated for the season. Ravens used the roost 2 months longer in 1986 than in 1985. The roost was abandoned between 16 and 23 October in 1986, as opposed to 7 to 9 August during 1985.

Ravens' use of tower sections in 1986 approximated their use of tower sections before shields and pegging were installed (Table 4). Decreased use of the C sections due to pegging was compensated by increased use of the shield wires (AW) and the D section.

Shields and pegging continued to be effective in preventing insulator contamination. Contamination levels were very low throughout the year (Table 2), and did not appear to vary in response to numbers of ravens. It is likely that the small amount of variation observed was the result of measurement error. Many strips of pegging detached from towers at and adjacent to the Wilson Creek Roost during 1986. By October, more than 100 strips of pegging had fallen from towers. The nylon bands used to secure pegging to the tower lattice appeared to have deteriorated. Loss of pegging accounted in part for the 3% of ravens that roosted on C sections during 1986. Some of these birds roosted in gaps where pegging had fallen from the lattice, while others roosted on the inner portion of the C sections, which were shielded rather than pegged. Loss of pegging from the outer C sections did not appear to result in increased contamination of the outer insulator strings. Mean scores of the outer insulators did not increase as the season progressed (Fig. 6).

Movements and Habitat Use

Thirteen ravens were captured during 907.7 trap hours. All were captured with leghold traps, although other types of traps were used during 326.7 trap hours (36.0%, Table 5). Success rates of leghold traps were highest during autumn and winter, and lowest during summer (Table 6). Three fledgling ravens were equipped with transmitters.

From November 1985 to October 1986, we obtained 1,425 locations from 24 transmitter-equipped ravens. Most locations (1,322, 93%) were obtained while tracking focal ravens; the rest (103, 7%) were incidental observations. Sample sizes ranged from 1 to 283 locations per bird ($x = 59 \pm 78$ locations, N=24) (Table 7). Most (1,244, 87%) locations were obtained from ravens captured during this period, although 9 of the 11 transmitter-equipped ravens thought to be alive in October 1985 were observed this year. We observed transmitter-equipped ravens for a total of 727.4 hours. Observations ranged from 0.3 to 134.2 hours per bird ($x = 45.5 \pm 41.8$ hours, N=16) (Table 7). Movements and habitat use data have not been analyzed. They will be reported in the final study report.

Food Habits

All pellets collected from April 1985 to March 1986 have been analyzed. Results have been tabulated, but have not been analyzed. These data will also be presented in the final study report.

Table 4. Distribution (%) of ravens among tower sections at the Wilson Creek Roost, 1985-86.

	C	AX	AW	B	D	W	E		Above[1]	Below[2]
1985										
Before Installation	20	33	<1	34	12	<1	<1	=	88	12
0-3 Weeks After Installation	0	24	2	11	63	0	0	=	37	63
4-6 Weeks After Installation	1[3]	24	31	20	24	0	0	=	76	24
1986	3	33	16	30	18	<1	<1	=	82	18

[1]Above insulators (C, AX, AW, B).

[2]Below insulators (D, W, E).

[3]All these ravens roosted on the shielded portion of the C sections.

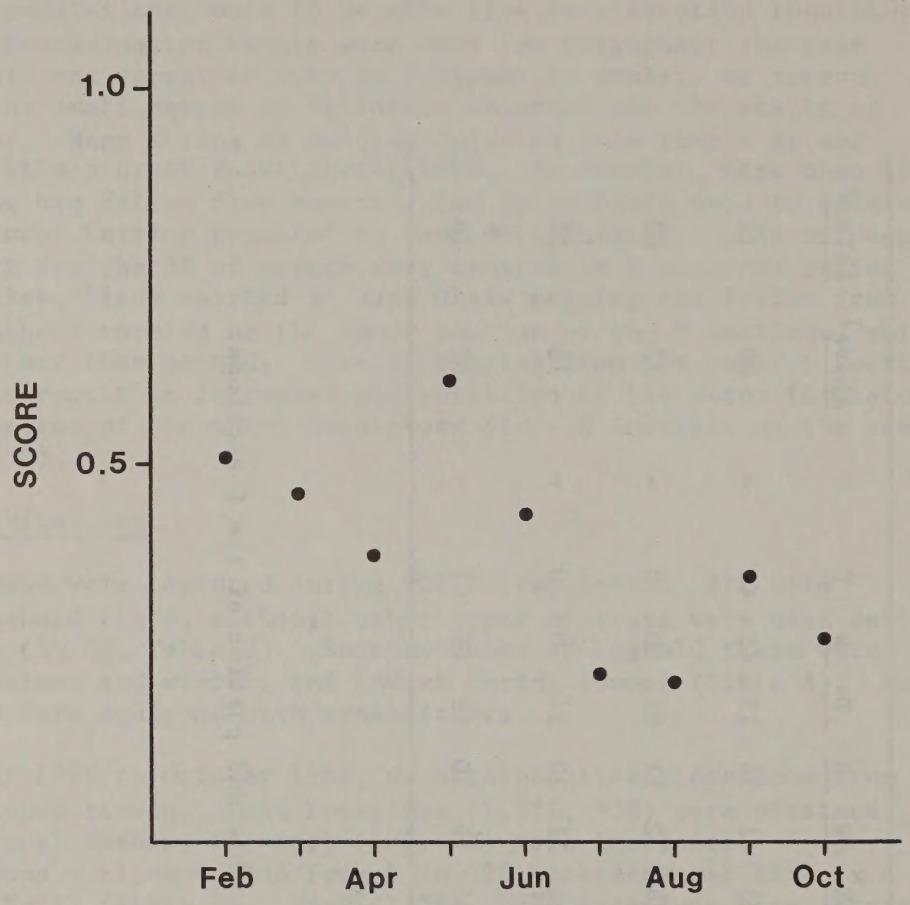


Fig. 6. Mean contamination scores of bells on outer insulator strings (protected by pegging) of towers used by ravens at the Wilson Creek Roost (miles 131-132), February - October 1986.

Table 5. Success rates of different types of traps used to capture common ravens, November 1985 - October 1986.

Type of Trap	No. Ravens Caught	Trap Hours	Trap Hours/Raven
Leghold Traps	13	581.0	44.7
Drop-in Trap	0	233.8	
Rocket Net	0	52.6[1]	
Bal-chatri Trap	0	22.4	
Net Gun	0	17.9	
Total	13	907.7	69.8

[1]The net was not fired on 2 occasions when a single raven could have been captured.

Table 6. Success rates for leghold traps with respect to season, November 1985 - October 1986.

Season	No. Ravens Caught	No. Magpies Caught	Trap Hours	Trap Hours/Raven	Trap Hours/Magpie
Winter (Dec, Jan, Feb)	3	2	62.6	20.9	31.3
Spring (Mar, Apr, May)	4	3	183.4	45.9	61.1
Summer (Jun, Jul, Aug)	1	0	210.4	210.4	
Autumn (Sep, Oct, Nov)	5	10	124.6	24.9	12.5
TOTAL	13	15	581.0	44.7	38.7

Table 7. Observation effort, transmitter-equipped ravens, November 1985 - October 1986.

Bird No.	Age[1]	Date Marked	Roost[2]	No. Locations[3]	Observation Hours
1	A	18 Apr 85	MSW	1*	
2	S	25 Apr 85	WC	1*	
4	A	30 Apr 85	WC	2*	
6	A	18 May 85	IP	2*	
8	S	6 May 85	MD	1*	
10	J	3 Apr 86	SFR	177	98.8
12	A	27 Jun 85	MD	1*	
13	A	2 Jul 85	WC	139	29.5
14	S	19 Aug 85	MD	26*	
15	A	11 Feb 86	MSW	27	15.6
16	A	16 Nov 85	IP	55	24.3
17	A	24 Feb 86	MSW	64	20.4
20	F	21 Jun 85	IP	8*	
21	A	26 Feb 86	MSW	195	83.3
22	S	30 Apr 86	WC	139	95.1
23	A	12 Apr 86	MSW	283	134.2
24	A	18 May 86	WC	2	0.3
25	F	22 May 86	IP	94	74.6
26	F	3 Jun 86	MSW	8	16.1
27	F	5 Jun 86	MD	24	28.2
28	A	28 Jun 86	MD	108	80.2
30	A	20 Oct 86	MSW	45	17.6
31	A	29 Oct 86	MSW	10	3.6
32	J	30 Oct 86	MSW	13	5.5
Total				1,425	727.4

[1]Age when marked: A = adult (ASY), S = subadult (AHY), J = juvenile (HY), F = fledgling.

[2]IP = Initial Point, MD = Marsing Dump, MSW = Marsing Southwest, SFR = Swan Falls Road, WC = Wilson Creek.

[3]Starred sample sizes represent incidental observations only; these birds were not tracked this year.

DISCUSSION

Use of Roosts

Occupancy of roosts was similar to 1984 and 1985. The Marsing Southwest Roost was used most heavily during autumn and winter, while other roosts were used predominantly during spring and summmer. The Initial Point Roost remained the largest roost on the line, both in terms of numbers of ravens and numbers of towers. The peak count of 1,226 ravens recorded there was 14% higher than 1985's high count (1,075 ravens), although both years' peak counts are considerably lower than the peak count of 2,103 ravens recorded during 1984. In all 3 years, peak use of the roost occurred during mid- to late summer. The peak count of 540 ravens recorded at the Swan Falls Road Roost during March is a new high for that roost. Trends in the overall roosting population were similar to previous years, peaking during mid-summer to early autumn.

Contamination

Peak contamination levels at the Marsing Southwest Roost occurred during late winter. Peak levels coincided with a fault that occurred on 1 February during cool, foggy weather. Examination revealed that flashovers had occurred at towers 155/3 and 155/4, the 2 most heavily contaminated towers at the roost (M. Mulrooney, pers. commun.). Laboratory tests of center phase insulators from towers 155/3 and 155/4 revealed that insulator efficiency had been seriously reduced by contamination (Wright 1986).

Peak contamination levels at the Initial Point and Marsing Dump roosts occurred during late summer, while contamination levels at the Wilson Creek Roost were low throughout the year due to pegging and shields. On an overall basis, contamination levels peaked in late summer, declined gradually from autumn through spring, and increased again starting in early summer.

Towers at the Marsing Southwest Roost had the highest mean contamination scores throughout the year, although some towers at other roosts were as heavily contaminated. Ravens at the Marsing Southwest Roost concentrate on fewer towers than at other roosts, and a greater proportion of ravens roost above insulators (Young and Engel 1986). Hence, all towers receive substantial contamination.

Evaluation of Shields and Pegging

Shields and pegging continued to effectively prevent insulator contamination. Ravens reoccupied the roost within a week of the date that the roost was reoccupied in 1985, before shields and pegging were installed. Ravens' distribution among tower sections was even more similar to pre-installation distribution than it was at the end of the 1985 roosting season. Decreased use of pegged sections appears to have been compensated by use of the shield wires (AW) and increased use of the D section.

1987 DATA NEEDS

Evaluation of shields and pegging should continue during 1986; the long-term effectiveness of these devices needs to be monitored. Surveys to locate occupied roosts, monthly coordinated roost watches, and monthly contamination estimates should also continue. These will allow us to monitor the roosting population and contamination levels, and will improve our understanding of occupancy of traditional roosts and seasonal trends in numbers. Weekly roost watches at major roosts in the study area, together with monthly contamination estimates, will allow us to better define the relationship between numbers of roosting ravens and specific contamination levels. Telemetry work should continue through February 1987. This will increase our knowledge of movements and habitat use during winter. To date, most movements and habitat use data have been collected during other seasons. Further engineering tests to relate specific contamination levels to specific increases in insulator conductivity are also needed.

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TITLE: Behavior and Productivity of Nesting Prairie Falcons in Relation to Construction Activities at Swan Falls Dam.

COOPERATORS: Idaho Power Company
Pacific Gas and Electric Company

INVESTIGATOR: A.M.A. Holthuijzen, Principal Investigator, Idaho Power Company

OBJECTIVES:

1. To evaluate the possible effects of construction and recreational activities on the behavior and productivity of nesting prairie falcons.

2. To establish a data base from which raptor management guidelines can be developed for industries and government agencies as well as for the BOPA.

SUMMARY

The objectives of this study are to: (1) evaluate the possible effects of construction and recreational activities in the Snake River Birds of Prey Area (BOPA) on the behavior and productivity of nesting prairie falcons, and (2) determine the long-term effects of experimental blasting on occupancy and productivity of nesting territories exposed to blasting in 1985 (Holthuijzen 1985). In 1986 reconstruction of the Swan Falls spillway was completed. Heavy construction continued throughout the nesting season.

The 1986 study was conducted from March through mid-July. A total of 13 pairs of prairie falcons was observed: 4 pairs exposed to construction actvities, 4 to recreation, and 4 pairs that served as controls. One pair was used to evaluate the effects of observation techniques on nesting falcons. Prairie falcons re-occupied 4 of 7 traditional nesting territories in the construction area; 2 were located 40-60 m above the new access road. One of the vacant territories was situated along the road, and 2 vacant sites were not on the road. Six of 8 traditional nesting territories in the area exposed to recreational activities which were occupied each year from 1976 to 1978 were used in 1986. Two variables measuring human activity (traffic flows and people weighted by their actvity) were used to evaluate the effects on prairie falcon behavior during the nesting season. Traffic flows in the Swan Falls study location were similar to traffic flows recorded in the same period (March-June) in 1985. The total number of recreational users was estimated at 7,000, a 13% decline compared to 1985. Sound levels were measured, but data are not available to be included in the analysis. Weak associations between human activity and behavior variables were found, but were related to recreational use of the Swan Falls area, not to human activity influencing falcon behaviors. Behaviors of prairie falcons did not differ substantially among the 3 study locations. Falcons exposed to blasting in the Swan Falls study location showed a short instantaneous reaction to blasting (<3 min) and no substantial differences in their behaviors compared to

falcon pairs not exposed to blasting. All 4 nesting territories used in the blasting experiment in 1985 were occupied in 1986, and 3 successfully fledged young. Four nesting territories which were not found in 1985 in the Reynolds Creek study location were located; 2 of these nesting pairs were successful. Six of 13 observed pairs failed in their nesting attempt in the BOPA. Estimated hatching dates did not significantly differ among the 4 study locations. However, hatching dates were on average 13 days later in the BOPA than in 1984 and 1985. Pairs starting incubation prior to 15 April showed better reproduction than pairs starting incubation after 15 April. I hypothesize that condition of the female falcon prior to egg-laying, modified by the proficiency of males to provide prey during the pre-incubation stage, determined incubation date. The breeding cycle of late nesting pairs was asynchronous with Townsend's ground squirrel numbers. Two of 6 early nesting pairs and 4 of 7 late nesting pairs failed. Young of late nesting pairs weighed less than young of early nesting pairs.

INTRODUCTION

Continued Research at Swan Falls

The reconstruction of the Swan Falls hydroelectric power plant located in the Snake River Birds of Prey Area (BOPA), scheduled to take place from 1983 through 1987, prompted a cooperative agreement between the Idaho Power Company (IPC) and the Bureau of Land Management (BLM), Boise District, to evaluate possible effects of construction activities on nesting prairie falcons (Falco mexicanus). In 1985 Pacific Gas and Electric Company joined the research effort. The study, which was initiated in 1984, has 2 objectives: (1) to evaluate possible effects of construction and recreational activities on the behavior and productivity of nesting prairie falcons, and (2) to establish a data base from which raptor management guidelines can be developed for industries and government agencies as well as for the BOPA (Holthuijzen 1984, 1985).

In 1986 reconstruction of the Swan Falls spillway was completed. This included demolition of the old spillway, building the new spillway, installing the floodgates, and removing the cofferdams and temporary bridges (Appendix I). Heavy construction continued throughout the nesting season. The objective of the 1986 study in the Swan Falls area was to continue monitoring the behavior and productivity of nesting prairie falcons for possible effects of construction activities.

Continued Research at Reynolds Creek

The blasting experiment in Reynolds Creek was completed in 1985. However, because there may be a lasting effect of blasting on occupancy of exposed aeries in Reynolds Creek, a survey was carried out to determine occupancy and productivity of nesting territories which had and had not been exposed to blasting in 1985.

STUDY AREA

Three of the study locations, Swan Falls, Dedication Overlook and Tick Basin, were located in the BOPA (Fig. 1), which is administered by the BLM, Bruneau Resource Area. Swan Falls is the study location exposed to the effects of industrial construction. Observations in the Dedication Overlook study location were continued to evaluate the possible effects of recreational activities on nesting prairie falcons. Tick Basin, located approximately 4 km upstream from Swan Falls Dam, served as the control study location. The Basin is largely inaccessible to vehicles and is exposed to minimal human activities (A. Holthuijzen, unpubl. data). The BOPA is situated in the Western Intermountain Sagebrush Steppe (West 1983). Detailed descriptions of the climate, vegetation, and natural environment of the BOPA can be found in U.S. Dep. Inter. (1979) and West (1983).

The Reynolds Creek study location is situated in the foothills of the Owyhee Mountains, outside the BOPA (Fig. 1), and has an elevation about 650 m higher than that of the BOPA. The annual precipitation averaged 280 mm over a 20 year period (1962-1982, Hanson 1983), and the average annual temperature was 7.2°C as measured at the Reynolds Creek Agricultural Research Service station. Detailed descriptions of climate, vegetation, and geology can be found in Hanson (1983) and Stephenson (1977).

In 1986 average monthly temperatures were about 3°C higher than normal in February, March, and June; about average in April and May; and 3°C below average in July at both Swan Falls and Reynolds Creek (Table 1). Late winter and early spring were wet, with precipitation 50% above average at Swan Falls. Early summer, however, was dry, with precipitation 75% below normal in June and July at Swan Falls and Reynolds Creek.

METHODS

Quantification of Human Activities

As in previous field seasons, 4 variables of industrial and recreational activities were measured: (1) sound levels (dB), (2) traffic flows (daily number of vehicles passing specific points), (3) heavy or noisy machinery (daily number of trucks over 2 tons or excessively noisy machinery passing through the study locations), and (4) recreational activity (daily numbers of visitors, their locations and the activities they engaged in). Sound levels and traffic flows were determined only in the Swan Falls and Dedication Overlook study locations. Sound levels were measured using an industrial sound level dosimeter (Micro-15 noise dosimeter, Quest Electronics, Oconomowoc, Wis.). Equivalent sound levels were measured daily during working hours near the Swan Falls Dam Power house or at 1 of 3 blinds near Swan Falls Dam (Swan Road N Side, Falcon Flats Fingers, and Swan Dam Road Turn; Fig. 2). At these 4 locations sound measurements were taken sequentially over a period of 4 days.

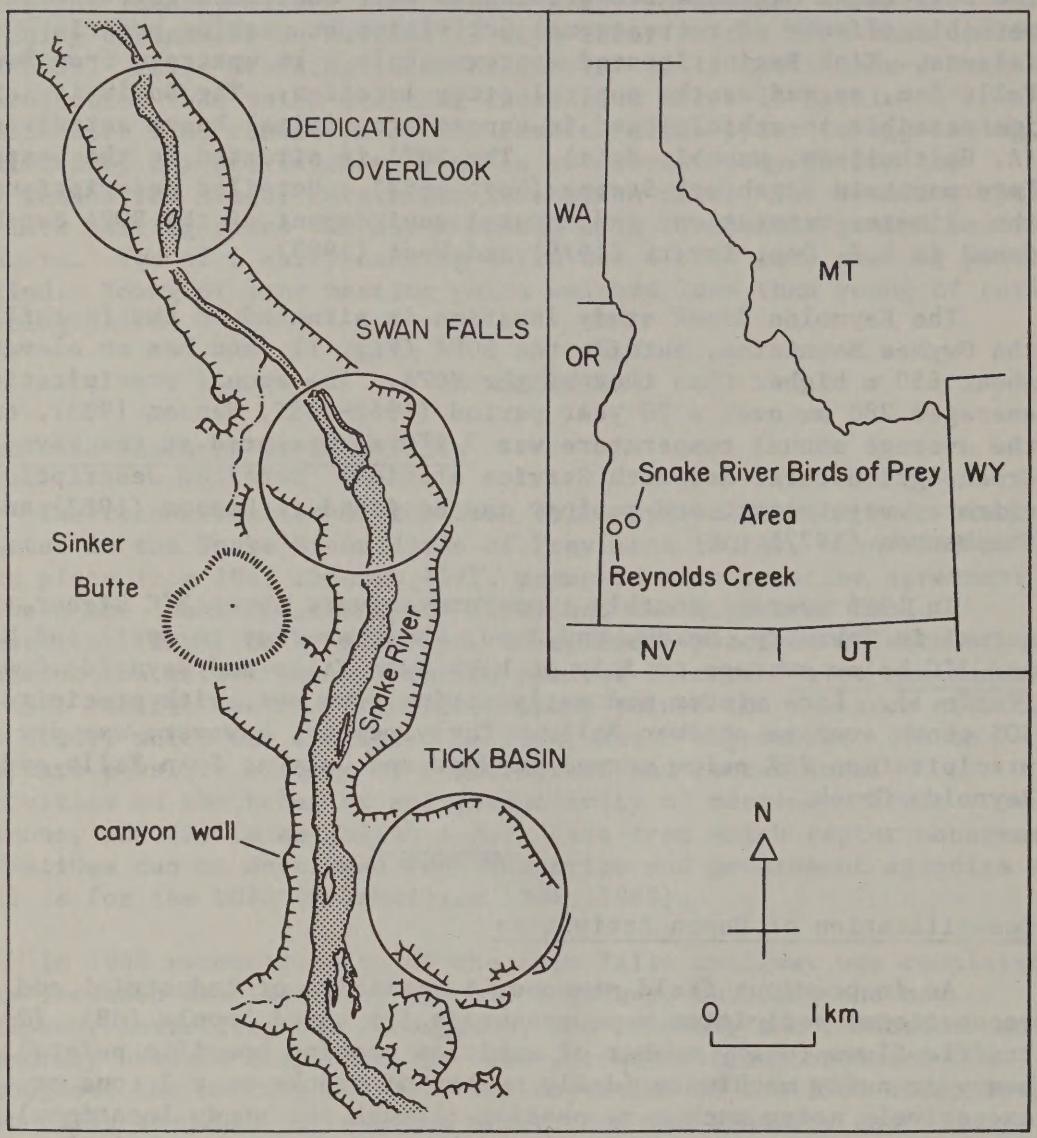

Fig. 1. Location of the study area.

Table 1. Weather information at Swan Falls and Reynolds Creek, January-July 1986 and 1950-1980.

Swan Falls

Month	1986 Max Temp (°C)	1986 Min Temp (°C)	1986 Mean Temp (°C)	1950-1980 Max Temp (°C)	1950-1980 Min Temp (°C)	1950-1980 Mean Temp (°C)	1986 Precip. (mm)	1950-1980 Precip. (mm)
January	5.7	-3.4	1.1	4.9	-3.6	0.7	16.8	22.3
February	11.8	2.0	6.9	9.5	-1.1	4.2	55.6	11.9
March	18.3	4.6	11.4	14.3	1.0	7.7	39.1	15.0
April	19.5	4.5	12.0	19.7	4.6	12.2	24.1	22.3
May	25.9	9.2	17.5	25.5	9.2	17.2	25.9	25.6
June	34.7	15.8	25.3	30.1	13.4	21.8	6.4	22.6
July	33.5	15.9	24.7	36.0	17.6	26.8	0.0	4.3

Reynolds Creek

Month	1986 Max Temp (°C)	1986 Min Temp (°C)	1986 Mean Temp (°C)	1964-1984 Max Temp (°C)	1964-1984 Min Temp (°C)	1964-1984 Mean Temp (°C)	1986 Precip. (mm)	1962-1981 Precip. (mm)
January	6.0	-4.8	0.7	2.9	-5.8	-1.5	17.3	36.0
February[1]	-	-	-	6.0	-3.7	1.2	-	19.8
March	14.4	0.3	7.4	9.2	-2.6	3.3	27.4	22.5
April	14.4	0.7	7.6	13.0	-0.2	6.4	28.2	25.3
May	20.6	4.5	12.6	19.1	3.9	11.5	22.4	22.0
June	29.3	11.0	20.2	24.0	8.0	16.0	6.4	32.5
July	27.8	10.1	18.9	29.7	11.6	20.7	7.9	7.1

[1]No information available

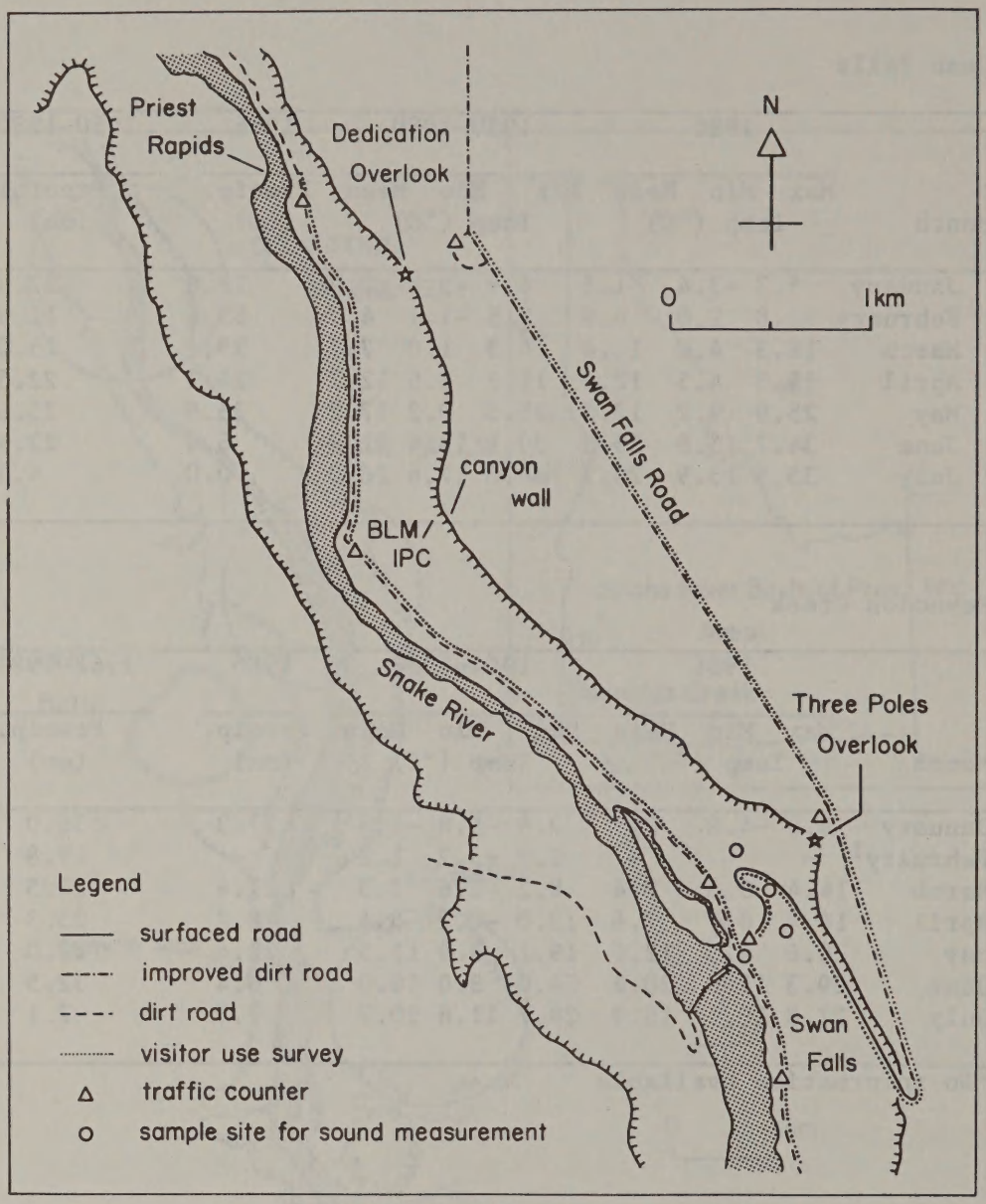

Fig. 2. Locations of traffic counters, sample sites for sound level measurements, and the visitor use survey route.

Traffic flows were measured with traffic counters (Autocount Cumulative Counter, Highway and Traffic Data Systems, Golden River Corp., Rockville, Md.) placed at (1) the Swan Falls access road, (2) 250 m upstream from Swan Falls Dam on the road parallelling the Snake River on the east side, (3) 250 m downstream on the road parallelling the Snake River on the east side, (4) the property line between BLM and IPC land downstream from the dam, (5) Priest Rapids, (6) Dedication Overlook, and (7) Three Poles Overlook (Fig. 2). Traffic flows on the west side of the Snake River were not measured because the traffic counter was stolen. Data were collected daily at all locations from late March through June. Heavy or excessively noisy machinery was recorded by observers in all study locations as in the 1984 and 1985 field seasons (for details see Holthuijzen 1984).

Traffic flows were calculated separately for weekdays and weekends because most recreational use of the Swan Falls area takes place during weekends (Holthuijzen 1984). All traffic accessed the Swan Falls area by the Swan Falls access road. Construction traffic was estimated by subtracting the recreational and residential flows from the daily traffic flow entering the Swan Falls area from the Swan Falls access road. Recreational traffic flows were recorded at counters located 250 m upstream and downstream from Swan Falls Dam. Residential traffic flows were estimated from flows measured in 1985 before construction started (Holthuijzen 1985:86) because flows were assumed to have remained relatively constant over time. The residential traffic flow may have been slightly overestimated in 1985 because some recreational vehicles would stop at Swan Falls Dam.

Recreational activities (numbers of people, their locations and activities) were evaluated by 2 complementary methods: (a) daily recreational surveys of the Swan Falls and Dedication Overlook study locations, and (b) observations from blinds by field personnel in all study locations. Seventy-three recreational surveys were carried out from late March through June along a fixed route (Fig. 2). Surveys started between 1400 and 1500 ($\bar{x}$=1430±30 min; N=70), when peak recreational use generally occurs (Holthuijzen 1984). The surveys lasted approximately 1 hour ($\bar{x}$=62±23 min, range=30-153 min; N=66). Data were collected on the distribution of visitors, their vehicles, and camp sites by plotting their locations on 1:24,000 topographic maps. Group sizes and activities of visitors were also recorded. Activities of visitors were subjectively weighted according to their potential to disrupt nesting raptors (Table 2). Number, sex and approximate age (<19 years, 19-65 years, >65 years) of occupants of each encountered vehicle were recorded, as were the type of vehicle and the license plate prefix. License plates provided information on the origin of the visitors. Based on the number, location, and activities of visitors, a visitor use index was calculated for each day for the the Swan Falls and Dedication Overlook study locations.

The total number of visitors over the period March through June was estimated by multiplying the daily number of vehicles entering the canyon along the Swan Falls access road (divided by 2 since vehicles entering the area generally leave by the same route) by the average number of occupants per vehicle.

Table 2. Numbers of recreationists observed during visitor surveys in the Swan Falls area, March-June 1986.

Activity	No. of people	Frequency (%)	Weight[1]
Birdwatching	97	5.8	1
Sightseeing	274	16.4	1
Camping	101	6.0	1
Fishing	506	30.2	1
Boating (motor)	105	6.3	1
Boating (no motor)	46	2.7	1
Outfitter	32	1.9	1
In parked vehicle	18	1.1	1
Other	457	27.3	1
Subtotal	1636	97.7	
Shooting	0	0.0	3
Rock throwing	3	0.2	2
ORV	35	2.1	2
Climbing	0	0.0	2
Subtotal	38	2.3	
Total	1674	100.0	

[1]Weight assigned to recreational activity

Continuous Behavioral Observations

Training of Field Personnel

The monitor room at the Peregrine Fund Inc.'s World Center for Birds of Prey was made available to field personnel for observing captive peregrine falcons to train assistants to (1) become familiar with the behavior of large falcons, (2) make accurate and consistent observations on the behaviors of the falcons, and (3) take and standardize field notes. Later, the principal investigator spent at least 1 full observation period with each field assistant in a blind during which period field notes were independently recorded. Notes were compared after the observation period to further standardize observation techniques and maximize data consistency.

Field Methods

During the last 2 weeks of March all occupied prairie falcon nesting territories were located in the Swan Falls, Dedication Overlook and Tick Basin study locations. An aerie is here defined as the physical location at which a falcon pair nested or attempted to nest. The nesting territory includes the aerie and the immediate area around it patrolled and defended by the pair. In each of the 3 BOPA study locations 4 aeries were used. Behavioral observations were made from blinds at an average distance of 132 m from the aeries (range=95-190 m) (Table 3), except at Halverson Lake where observations were conducted in the open on a rock outcrop. At Halverson Lake I decided not to use a blind because this would have attracted recreationists, thereby interfering with observations. All blinds were situated below the aerie. The blinds were always accessed by foot along the same route. None of the access trails took the observer closer to the aerie than the distance at which the blind was placed.

Observational methods were the same as those employed during previous field seasons (Holthuijzen 1984, 1985). Observations started 30 min before sunrise and were terminated 30 min after sunset. An entire day was chosen as a sampling unit to avoid sampling problems related to daily behavioral cycles of the falcons (Altmann 1974; Fraser 1984). Aeries located in Tick Basin were observed once every 6 days. In the Swan Falls and Dedication Overlook study locations observations were concentrated on days when peak human activities were expected. In the Dedication Overlook study location observations were conducted on Saturdays when visitor use is high (Holthuijzen 1984). This included Halverson Lake which is located approximately 6 km downstream from Dedication Overlook and receives heavy recreational use during the spring (S. Addington and M. Kochert, pers. communs.). In the Swan Falls Dam study location sampling days were scheduled on weekdays when construction took place. When disruptive activities (e.g., blasting) took place, observations were concentrated on those aeries which were most likely to be affected. The potential effect of construction activities on an aerie was judged by the distance of the disturbance source(s) from the aerie. A sampling schedule in the Swan

Table 3. Distances (m) from blinds to prairie falcon aeries.

Aerie	Distance (m) 1984	1985	1986
Swan Falls			
Swan Dam Three Poles	200	170	-
Swan Dam Road Turn	-	-	137
Swan Road N Side	225	190	190
Ferry	140	146	-
Falcon Flats Fingers	250	177	159
Falcon Flats Brown Rock	-	-	164
Dedication Overlook			
Priest Rapids I	250	230	-
Camera	-	137	114
PF I	155	-	-
PF II	190	173	118
Dedication Site	-	-	105
Halverson Upper Lake	-	-	105
Priest Upper	170	160	123
Tick Basin			
Tick I	-	125	95
Tick II	-	182	182
Tick III	-	105	105
Red Trail	-	135	-
San Sebastian Basin	-	-	114
Reynolds Creek			
Reynolds Lower	-	70	-
Reynolds Midcanyon Downstream	-	105	-
Reynolds Upper Road	-	150	-
Reynolds Midcanyon Cup	-	137	-
Mean	198	150	132

Falls study locations of 1 observation day each 6 days was adhered to as closely as possible.

Overall, an average of 15 (SD=1) days of observation were conducted at each aerie (range=5-17 days). Observations were carried out by 2 observers working in shifts of equal length (5-8 hours) to avoid observer fatigue and ensure data quality. Observers were systematically rotated through all observed aeries to minimize observer bias. A 10-45x Bushnell telescope and 7-10x binoculars were used to make observations. The breeding season was divided into 4 distinct stages: pre-incubation, incubation, brood-rearing, and post-failure (i.e., behavioral observations after failure of a nesting attempt). Hatching dates were estimated by back-dating using the ages of young estimated with a photographic aging key (Moritsch 1983). Laying dates were calculated based on a 34-day incubation period (Burnham 1983).

Observations started during the last week of March at the 3 BOPA study locations. They continued until the nestlings were 30 days of age (early June to mid-July) or the nesting attempt failed. At each aerie an average of 3.5 (SD=2.5) days (range=0-9 days) of observations were made during pre-incubation, 5.5 (SD=1.8) days (range=1-8 days) during incubation, 3.0 (SD=2.0 days) days (range=0-5 days) during brood-rearing, and 1.2 (SD=2.0) days (range=0-7 days) during post-failure. The aeries were observed for an average of 193.4 (SD=48.0) hours (range=100-272 hours) totalling 2,514 hours for all aeries combined (Table 4). Nest failures occurred in all 3 BOPA study locations (Swan Falls: Falcon Flats Brown Rock and Falcon Flats Fingers; Dedication Overlook: PF II, Dedication Site, and Halverson Upper Lake; Tick Basin: San Sebastian Basin). Nest failures took place late in the nesting season except at Dedication Site which failed during early incubation. Therefore, observations could not be shifted to another aerie. In addition, replacement aeries were not available.

Separate records were collected for the male and female falcon forming a pair. Sex was determined in part by behaviors such as position of the birds during copulations (reverse mountings have not been observed in prairie falcons; Evans 1982) and food begging by the female. Individual variation in plumage pattern and the larger body size of the female were also used for sex determination. Finally, a stylized drawing was made of the facial pattern and body of each bird. They were used as quick references by the observers. For each sex, behavioral information on the time (min) spent on pre-defined activities was collected continuously (Table 5 and Appendix II). The frequency and time at which patrols, copulations, prey deliveries, caches, retrievals, and perch relocations occurred during an observation day were also recorded for each sex. Interactions between the territorial pair, conspecifics, and other birds or mammals were classified as aggressive, non-aggressive, or defensive (Appendix II). Panoramic photographs taken of the cliff section where the aerie was located were used to map perching locations, patrolling routes and encounters between the residential pair and other birds or mammals. Data on behaviors of nestlings were not collected.

Table 4. Observation effort during the 1986 nesting season.

Study location	No. aeries	No. days	No. hours
Swan Falls	4	52	781
Dedication Overlook	5	61	914
Tick Basin	4	55	819
Total	13	168	2514

Table 5. Behavioral categories used in continuous observations of prairie falcons during the 1986 nesting season.

Duration	Frequency	Maps
perching	patrol	perching distance
preening	aggressive encounter	to scrape
incubating	copulation	patrolling routes
brooding	relocation	
nest visit	prey delivered	
out-of-sight	prey cached	
in scrape out-of-sight	prey retrieved	
in canyon out-of-sight		
flight-in-canyon		
flight-out-of-canyon		
feeding (adult/chick)		

Reaction of Falcons to Blasting at Swan Falls Dam

Blasting at Swan Falls Dam took place from 7 April through 13 May. Generally, only 1 blast took place per day, but on occasion 2 occurred. Most blasts were set off at 1630, but if 2 blasts were conducted, the first took place at 1200. Aeries in the Swan Falls study location were an average 810±205 m (N=4) (range=560-1000 m) from the dam.

Commonly observed behaviors of falcons (e.g., perching, incubating, and brooding) were recorded continuously from a maximum of 30 min prior to a scheduled blast to a maximum of 30 min after a blast. I used readjustment time as a measure of how falcons reacted to a blast. The readjustment time was defined as the period which elapsed until the falcons resumed the behavior they had been engaged in immediately before the blast. Only observations when the birds were known to be in the nesting territory at the time of the blast were included in analyses. Observations were made at all 4 nesting territories in the Swan Falls study location but because of personnel limitations not all nesting territories were observed during a single blast. I concentrated observations on pairs which were incubating.

Reaction of Falcons to Observers

The potential effect of an observer on prairie falcon pairs under observation was evaluated by comparing behavior of falcons before, during, and after the approach of an observer to a blind; generally during the mid-day shift. I assumed that at this time the falcons were most likely to be disturbed by observers. In the morning the observers arrived at the blinds before sunrise and in the evening they left after sunset, when the birds were usually roosting. A change in behavior of a falcon during the time an observer was in view while approaching or leaving a blind was considered a reaction to the observer. Blinds were always approached by foot for the last 400 m along the same access route. Motorcycles were not used within a 400 m radius from the blinds. Information on observer impacts on prairie falcon behaviors was not collected for the Halverson Upper Lake pair because observations were made in the open. Also, it would have been difficult to decide to which human activity the falcons may have reacted because at the mid-day shift considerable recreational activity often took place. Much of this activity occurred between the observer and the aerie.

Observing from Within and Outside a Blind

The Priest Upper aerie in the Dedication Overlook study location on the west side of the Snake River near the abandoned Priest Ranch, is exposed to low levels of visitor use. Therefore, I considered this aerie unsuitable for evaluating potential effects of human activities on nesting falcons. The aerie could not be used as a control because some human activity occurs there. I decided to use this aerie to study the effects of collecting data from within or outside a blind on the falcons' behavior. Observations were made once every 6 days by the same pair of observers alternately sitting inside

or outside the blind during morning or afternoon shifts on subsequent observation days. This enabled me to compare behaviors of the falcons among mornings and among afternoons of the same nesting stage.

Productivity and Occupancy

Productivity (young fledged per pair) of all nesting pairs under observation in the 3 BOPA study locations was determined by counting the number of chicks per occupied territory that reached 30 days of age. Regular ground surveys were conducted from late May through June to determine productivity of non-observed aeries within all study locations.

Surveys in Reynolds Creek started during the last week of March. I spent 3 weeks identifying the aeries and determining their occupancy. Productivity was determined by re-visiting all aeries at 2 week intervals starting in the middle of May. Nestlings were aged using the photographic aging guide (Moritsch 1983). Nestlings which were first observed when they were less than 30 days old were inspected again when they were an estimated 30 days old (i.e., 80% of the age at which young normally leave the aerie of their own volition; Steenhof 1987).

Weighing Nestlings and Inspecting Aeries

Nestlings at all identified aeries in all study locations were weighed and banded when they reached an estimated age of 30 days to obtain an index of their physical condition. Male and female prairie falcons vary considerably in size and in weight (Enderson 1964). Therefore, measuring body weight alone to determine condition would be misleading. Scaling weight by using an appropriate structural measurement has been found effective in other birds (Owen and Cook 1977, Wishart 1979, Johnson et al. 1985). Nestling weight was recorded to the nearest 5 g using a 1000 g Pesola spring balance. Crop fullness was estimated in increments of 25% to further reduce weight variation. Morphological measurements taken included wing chord (wing straightened but not excessively flattened); tarsus length and width (at the narrowest point); culmen width, depth and length; and footpad length (tip of the middle toe to the tip of the hallux with the foot fully extended). Nestlings were banded with a red laminated plastic band showing 2 unique white numbers (Ward 1975) on the left leg, and a U.S. Fish and Wildlife Service band on the right leg.

Climbing to the aerie and banding and weighing the young took an average of 97±23 min (range=58-130 min, N=13). To alleviate any possible stress to the nestlings all young were hooded when they were taken out of the aerie. They were then placed in snug-fitting cardboard tubes to avoid damage to the body and emerging feathers and to provide additional protection during handling. After measurements were taken the young were fed beef heart moistened with water. Measurements and banding were conducted in the morning hours (0600-0800) to avoid heat stress. Behaviors of adult birds were observed during banding. Observations began

when personnel arrived at the nest territory and lasted a maximum of 2 hours after the young were placed back in the aerie.

Data Analysis

The frequency at which certain behaviors occurred and the time engaged in pre-defined behaviors (Appendix II) were calculated for each aerie, observation day, and sex. Each observation day at a single aerie constituted the sample unit for all analyses. Two territories were excluded from these analyses. Halverson Upper Lake was not used because both the initial and re-nesting attempt failed soon after observations started. Priest Upper was not used because the pair was not subjected to the same levels of human activities as the other pairs in the Dedication Overlook study location.

Because day length increased from approximately 12 to 16 hours during the study period, direct comparisons of behaviors expressed in absolute time (min) could not be made. Therefore, the percentage of the daylight hours spent on each behavior was calculated. Percentage data were subjected to an arcsine-square root transformation to stabilize the variance and to conform the data to the normality assumption which is required for parametric statistical tests (Sokal and Rohlf 1981). Frequency data were not adjusted for day length.

Two approaches were used to test the possible effects of human activities on prairie falcon behavior. First, iterative principal factor analyses were used to test for associations between human activities and prairie falcon behavioral variables in the Swan Falls and Dedication Overlook study locations. Separate analyses were performed for males and females. In each analysis, the basic factor matrix was rotated using an oblique rotation technique (promax) to seek a simple structure and describe each factor with a minimum number of variables (Dillon and Goldstein 1984). Variables were considered to be either positively or negatively associated if they loaded significantly on the same factor (i.e., loadings greater than 0.30 or less than -0.30).

Two human activity variables, "people" and "traffic", were used in the factor analysis. The total number of visitors observed during the recreation survey weighted by their activities (Table 2) on a particular observation day was used to estimate "people" in the Swan Falls and Dedication Overlook study locations. Traffic flows on each observation day were measured by traffic counters at the Swan Falls access road and the border between BLM and IPC property to estimate traffic in the Swan Falls and Dedication Overlook study locations, respectively.

In the 2nd series of analyses, stepwise discriminant analysis was used to test for differences in behavior among the 3 study locations. Separate analyses were performed for males and females in each of 3 stages of the nesting season: pre-incubation, days -51 through 0; incubation, days 1 through 33; and brood-rearing, days 34 through 63. Additional multivariate analyses were performed to test for

differences in behavior between early and late nesters. Early nesters started incubation before 15 April and late nesters after 15 April.

All statistical analyses were carried out using the Statistical Analysis System (SAS Institute, Inc. 1982). Tests were evaluated at the 0.10 level of significance. Variation is expressed as standard deviations, unless otherwise indicated.

RESULTS

Human Activity

Traffic Flows

Weekday traffic flows along the Swan Falls access road averaged 211.0 vehicles/day. Flows increased to 236.8 vehicles/day on weekends (Table 6). Construction traffic accounted for more than half of the traffic flows on weekdays (118.8 vehicles/day), which concerned mostly construction personnel commuting to Swan Falls. Traffic flows at Dedication Overlook and Three Poles averaged 3.0 and 6.9 vehicles/day on weekdays, respectively, and tripled on weekends to 8.1 and 18.2 vehicles/day, respectively. Downstream traffic flows were about 3 times higher than upstream flows and averaged 13.6 versus 4.4 vehicles/day for weekdays and 39.4 versus 15.2 vehicles/day for weekends, respectively. Twenty percent of all vehicles entering the Swan Falls area on weekends moved either upstream or downstream. This suggests that the remaining 80% of the vehicles and their occupants stayed in close proximity to Swan Falls Dam. Seventy-seven percent of the vehicles venturing downstream entered BLM land, and 47% then continued past Priest Rapids.

Visitor Use Surveys

Only 2.3% of all visitors were involved in what we considered potentially disruptive human activities, mainly off-road vehicle use. In contrast to previous years, shooting and rock climbing were not recorded, and only 1 case of rock throwing occurred (Table 2). The main human activity was fishing (30.2%) followed by visitors driving their vehicles (27.3%) and people sightseeing (16.4%). Nine percent of all visitors were involved in motorized and non-motorized boating, and 6.0 and 5.8% of the visitors were engaged in camping and birdwatching, respectively.

Most vehicles carried Idaho plates (92.8%; N=569), predominantly from Ada (64.9%) and Canyon (12.6%) counties (Table 7). Four counties (Valley, Owyhee, Latah, and Boise) each represented about 1% of the reported vehicles. The remaining in-state vehicles (11.4%) carried license plates from 25 other Idaho counties. Out-of-state license plates comprised 7.2% of all recorded license plates, with Oregon, California, and Washington plates reported most frequently (29.5, 15.9, and 11.4% of all out-of-state vehicles; N=44). Vehicle occupancy averaged 2.2 (SD=2.6; N=774) persons/vehicle, including 1.5 adults/vehicle, 0.6 children/vehicle, and 0.1 persons older than 65 year/vehicle. Sixty-five percent of all visitors were males. The

Table 6. Traffic flows (vehicles/day) in the Swan Falls area, March-June 1986.

Location	Weekday			Weekend		
	Mean	SD	N	Mean	SD	N
Swan Road	211.0	75.9	61	263.8	122.1	25
Dedication Overlook	3.0	2.2	70	8.1	5.4	29
Three Poles	6.9	7.1	69	18.2	7.9	29
Residential	74.7	-	-	74.7	-	-
Construction	118.8	74.7	57	-	-	-
Upstream	4.4	4.6	68	15.2	10.6	28
Downstream	13.6	8.1	68	39.4	17.9	29
IPC/BLM	8.7	10.2	64	30.4	18.3	27
Priest Rapids	6.4	5.9	70	18.6	9.5	29

Table 7. Origins of vehicles based on license plates recorded during visitor use surveys in the Swan Falls area, March-June 1986.

Idaho County	Number of cars	% of total	U.S. State	Number of cars	% of total
Ada	398	64.9	Arkansas	1	2.2
Canyon	77	12.6	California	7	15.9
Valley	7	1.1	Colorado	3	6.8
Owyhee	6	1.0	Connecticut	1	2.2
Latah	5	0.8	Florida	1	2.2
Boise	6	1.0	Iowa	1	2.2
other	70	11.4	Nebraska	1	2.2
			Missouri	1	2.2
			Montana	3	6.8
			New York	1	2.2
			Oklahoma	1	2.2
			Oregon	13	29.5
			Pennsylvania	2	4.5
			Texas	2	4.5
			Utah	1	2.2
			Washington	5	11.4
Subtotal	569	92.8	Subtotal	44	7.2

total number of BOPA visitors from late March through June was estimated at 16,000 for weekdays and 8,000 for weekends, totalling 24,000 visitors (rounded to the nearest 1,000). When these figures are corrected for construction and residential traffic flows, total weekday visitor numbers amount to 1,000 and weekend visitors to 6,000, totalling 7,000 visitors. This figure suggested a 13% decline in visitor use compared with the same period in 1985 (Holthuijzen 1985).

Associations Between Human Activity and Behavioral Variables

Four common factors were extracted for both male and female falcons when behavioral data expressed in percentages were analyzed (Table 8). The 1st and 2nd factors for the male falcon presented a contrast between presence of the bird either inside or outside the canyon. One behavioral variable (preening) and the 2 human activity variables (people and traffic) loaded significantly on the 2nd factor. The 4th factor indicated a contrast between behaviors associated with the aerie versus outside the canyon. A similar pattern was shown by the 4 common factors extracted for the female falcon. Behaviors inside versus outside the aerie were associated (1st and 3rd factor) as well as presence and absence (4th factor). Again, preening loaded significantly with the 2 human activity variables (2nd factor).

Four common factors were extracted for behavioral data expressed in frequencies for both male and female falcons (Table 9). On the 1st factor of the male falcon, the variable traffic and behavioral variables aggression and prey delivery were positively associated and the variables people and relocation were negatively associated. The 2nd factor expressed territorial behavior because patrolling, aggression, nest visits, and prey deliveries all loaded significantly. This combination of behaviors was often observed during disputes between territorial pairs. Aggression, nest visits, and relocations loaded significantly on the 3rd factor, which may represent behaviors associated with increased levels of excitement in the falcon. The 4th factor may express early courtship behavior because patrolling and copulation, both common behaviors during pre-incubation, showed positive significant loadings. Although male falcons delivered prey to the female during pre-incubation, males were rarely observed consuming prey. This may explain a negative association between the behaviors feeding and prey delivery on the 4th factor. The 1st factor extracted for the female showed a positive association for the variables traffic, aggression, relocation, feeding, and prey delivery (patrolling, aggression, and copulation) and pre-incubation behavior in the 4th factor (copulation and nest visit). The variables traffic and prey delivery were positively associated on the 3rd factor, but both were related negatively to the variable people.

Differences in Behaviors of Falcons Among the Study Locations

Although differences were found for some behaviors expressed as percentages among the 3 study locations, the consistently low average squared canonical correlation coefficients (ASCC's) indicated poor discrimination (ASCC's<0.18; Table 10). Canonical correlations are the multivariate analogue of the univariate correlation coefficients.

Table 8. Factor matrix of human activity variables and behaviors of male and female prairie falcons (behaviors expressed as percentages of total observation time/day), nesting season 1986 (N=88 days used in analyses). Only loadings greater than |±0.30| are presented in the table.

	Male				Female			
	Common factor loadings				Common factor loadings			
Variables	I	II	III	IV	I	II	III	IV
People	-	0.93	-	-	-	0.80	-	-
Traffic	-	-0.63	-	-	-	-0.72	-	-
Perching	0.89	-	-	-	0.82	-	-	-0.42
Preening	0.86	0.39	0.30	0.49	-	0.36	-0.33	-0.44
Incubating/ brooding	-	-	-	0.97	-0.91	-	-0.51	-
Canyon flight	0.52	-	-	-	-	-	-	-0.45
Out-of-view	-	-	0.83	-	-	-	-	0.72
Out-of-canyon	-0.51	-	-0.86	-0.61	-	-	0.97	-
Perched out-of-view-	0.50	-	-	-	0.70	-	-	-

Table 9. Factor matrix of human activity variables and behaviors of male and female prairie falcons (behaviors expressed as number of counts/day), nesting season 1986 (N=88 days used in analyses). Only loadings greater than |±0.30| are presented in the table.

	Male				Female			
	Common factor loadings				Common factor loadings			
Variables	I	II	III	IV	I	II	III	IV
People	-0.57	-	-	-	-	-	-0.68	-
Traffic	0.96	-	-	-	0.57	-	0.89	-
Patrolling	-	0.71	-	0.32	-	0.85	-	-
Aggression	0.37	0.39	0.70	-	0.39	0.75	-	-
Copulation	-	-	-	0.60	-	0.67	-	0.51
Nest visit	-	0.95	0.48	-	-	-	-	0.96
Relocation	-0.35	-	0.69	-	0.72	-	-	-
Feeding adult	-	-	-	-0.39	0.61	-	-	-
Prey delivery	0.51	0.43	-	-	0.84	-	0.37	-

Table 10. Stepwise discriminant analysis to test for differences in behaviors of male and female prairie falcons (expressed as percentages of total observation time/day) among the 3 study locations for pre-incubation (N=37), incubation (N=52), and brood-rearing (N=34) stages, nesting season 1986 (Halverson Upper Lake and Priest Upper nesting territories excluded). N denotes the number of observation days used in the analysis. Only P-values <0.10 included.

	Pre-incubation						Incubation						Brood-rearing					
	Male			Female			Male			Female			Male			Female		
Variables	R^2	F	P	R^2	F	P	R^2	F	P	R^2	F	P	R^2	F	P	R^2	F	P
Perching	–	–	–	–	–	–	0.09	2.69	0.07	–	–	–	–	–	–	–	–	–
Preening	–	–	–	–	–	–	0.29	10.1	0.01	–	–	–	–	–	–	–	–	–
In aerie	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Incubating	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Brooding	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Canyon flight	0.12	2.43	0.10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Out-of-view	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Out-of-canyon	0.14	2.82	0.07	–	–	–	–	–	–	0.09	2.42	0.09	–	–	–	–	–	–
Perched out-of-view	0.12	2.48	0.09	–	–	–	0.08	2.36	0.10	–	–	–	–	–	–	–	–	–

ASCC male pre-incubation=0.14
ASCC male incubation=0.18
ASCC female incubation=0.12

Thus, ASCC values close to 1 would suggest substantial differences between groups and values close to 0 minor differences. The low ASCC values reflect minor differences in behaviors among the 3 study locations. Similar results were found when discriminant analyses were conducted on the behavioral data expressed in frequencies per day (Table 11). Again, differences were found in some behaviors, but the low ASCC values (ASCC's<0.19) suggested minor behavioral differences among the groups of nesting falcons in the 3 study locations.

Early and Late Nesting Falcons

Productivity of late nesters (1.1±1.6 young/attempt; N=8) was lower, but not significantly different, than that of early nesters (2.7±1.9 young/attempt; N=7) (Wilcoxon 2-sample test Z=1.53, P(Z>1.53)=0.12). Some differences were found for behaviors expressed as percentages of total observation time per day, but discrimination between the 2 groups was poor (ASCC's<0.01; Appendix III). Although differences were found for prey deliveries between early and late nesting males for each of the nesting stages, overall discrimination was poor between the 2 groups of falcons for behaviors expressed as counts per day (ASCC's<0.01); Appendix IV). Thus, the behavioral repertoire of late nesters apparently did not differ substantially from that of early nesters.

Behavioral Response of Falcons to Blasting

Observations were collected during 58 blasting instances in the Swan Falls study location, often at more than 1 aerie simultaneously. A total of 116 observations was available for male and female falcons combined. Only 68 observations were used in the analyses because only in these instances were falcons at or near the aerie. In 14 instances (20.6%) the falcons reacted to a blast (Table 12). The average readjustment time was 2.64±3.71 min (N=14). If instances are included when the falcons were present, but did not react to the blasting, the average readjustment time declined to 0.54±1.96 min (N=68). Readjustment time and the number of reactions did not differ among breeding stages (Kruskal-Wallis χ^2=2.32, df=2, P(χ^2>2.32)=0.31, and χ^2=1.32, df=2, P(χ^2>1.32)=0.51, respectively). Males reacted to blasting more frequently then females (χ^2=3.59, df=1, P(χ^2>3.59)=0.05).

The reaction to blasting was further evaluated by type of pre-blasting behavior as compared to post-blasting behavior. Pre-blast behaviors included perching (25.0% of all observations; N=68), preening (4.4%), flight-in-canyon (5.8%), perching out-of-view (8.8%), incubating (42.6%), brooding (10.3%), and nest visits (2.9%). Perched birds (N=17) generally remained perched (N=11), made a short flight in the canyon (N=4), or directed aggression towards neighboring raven (Corvus corax) pairs (N=2). Preening birds (N=3) continued preening. Flying falcons (N=4) continued circling (N=2), disappeared out of the canyon, or in 1 instance reacted aggressively towards an American kestrel (Falco sparverius). In 2 cases the female at Falcon Flats Fingers inspected a prospective aerie at the time of blasting; in one instance she did not visibly react and in the other case she flew off into the canyon. Brooding falcons (N=7) did not react.

Table 11. Stepwise discriminant analysis to test for differences in behaviors of male and female prairie falcons (expressed as counts/day among the 3 study locations for pre-incubation (N=37), incubation (N=52), and brood-rearing (N=34) stages, nesting season 1986 (Halverson Upper Lake and Priest Upper nesting territories excluded). N denotes the number of observation days used in the analysis. Only P-values <0.10 included.

	Pre-incubation						Incubation						Brood-rearing					
	Male			Female			Male			Female			Male			Female		
Variables	R^2	F	P	R^2	F	P	R^2	F	P	R^2	F	P	R^2	F	P	R^2	F	P
Nest visit	–	–	–	–	–	–	0.18	5.72	0.01	–	–	–	–	–	–	–	–	–
Patrolling	–	–	–	–	–	–	–	–	–	–	–	–	0.16	3.16	0.05	0.22	4.51	0.01
Aggression	–	–	–	0.15	3.10	0.05	–	–	–	–	–	–	–	–	–	–	–	–
Copulation	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Relocation	–	–	–	–	–	–	0.18	5.51	0.01	–	–	–	–	–	–	0.21	4.21	0.02
Feeding	–	–	–	0.16	3.29	0.04	–	–	–	–	–	–	–	–	–	0.17	3.24	0.05
Prey	0.13	2.55	0.09	0.14	2.97	0.06	–	–	–	–	–	–	0.17	3.32	0.04	–	–	–

ASCC male pre-incubation=0.06
ASCC male incubation=0.14
ASCC male brood-rearing=0.19
ASCC female pre-incubation=0.16
ASCC female brood-rearing=0.19

Table 12. Reactions of prairie falcons to blasting at Swan Falls Dam, 1986 nesting season.

Reaction	Nesting Stage[1] 1	2	3	Total
No change	78.3 (18)	84.4 (87)	69.2 (9)	79.4 (54)
Change	21.7 (5)	15.6 (5)	30.8 (4)	20.6 (14)

[1]=pre-incubation; 2=incubation; 3=brood-rearing

Table 13. Behavioral changes of prairie falcons when observers were approaching or leaving blinds.

Sex	No change (%)	Change (%)	N
Male	74.8 (110)	25.2 (37)	147
Female	84.2 (234)	15.8 (44)	278
Both sexes	80.9 (344)	19.1 (81)	425

Incubating falcons (N=29) generally continued incubating during a blast (N=27), or perched at the aerie entrance (N=2) and resumed incubation within 1 min.

Behavioral Response of Falcons to Observers

Behavioral data collected on prairie falcons while observers approached blinds were used to answer 2 questions: (1) did prairie falcons respond to approaching observers, i.e., did behavioral changes take place and if so, what sort of changes occurred?, and (2) did the distance from the blinds to the aerie influence the behaviors of falcons during such approaches? A change in behavior of a falcon under observation during the approach of an observer was considered a reaction to the observer. Falcons showed no response to an approaching observer in 344 out of 425 (80.9%) instances (Table 13). Males showed a higher reponse rate than females (25.2 versus 15.8%; $\chi^2=5.44$, df=1, $P(\chi^2>5.44)=0.02$). Numbers of behavioral changes observed per pair were not different among falcon pairs ($\chi^2=11.97$, df=11, $P(\chi^2>11.97)=0.36$). Likewise, the response of the falcon pairs did not change during the nesting season ($\chi^2=3.37$, df=2, $P(\chi^2>3.37)=0.18$). The post-failure stage was excluded from this analysis because falcons were absent from their nesting territories for long periods.

In 283 instances when observers were approaching or leaving blinds falcons were outside the canyon or out of view. When falcons were present common behaviors the birds engaged in were incubating (N=168), perching (N=136), brooding (N=36), preening (N=31), or perching out of view (N=25) (Table 14). Perching falcons generally remained perched (111 out of 136 instances), preened (N=4), entered the aerie to incubate (N=5) or brood (N=1), relocated (N=11), flew in or out of the canyon (N=2), fed on prey (N=1), or engaged in aggressive behavior (N=1). Incubating falcons continued incubating in 157 out of 168 instances; in 11 cases a bird left the aerie and perched or preened (N=2), flew out of the aerie and perched (N=4), flew in or out of the canyon (N=4), or showed aggressive behavior (N=1). Only in 1 out of 36 instances a brooding falcon left an aerie and subsequently engaged in aggressive behavior. In 19 out of 31 instances preening falcons continued to preen; in the other instances they perched (N=6), relocated (N=2), went into the aerie (N=2), or disappeared out of view (N=2). Falcons out of view remained out of view (75 out of 80 instances), perched (N=4), or flew in the canyon (N=1).

The distance from the blind to the aerie apparently did not affect the behaviors of the falcons, as was suggested by the non-significant relationship between the percentage of approaches which elicited a behavioral response per nesting territory and the distance from the blinds to the aerie (partial b=<0.01, t=0.07, P=0.94). Approach time, however, showed a positive relationship with percentage behavioral change (partial b=0.02, t=2.34, P=0.04). This is not surprising, since the probability of a behavioral change taking place will increase with time.

The question remained whether the number of observed changes in behavior differed from the expected number of behavioral changes

Table 14. Behaviors of prairie falcons when observers were approaching or leaving blinds.

Behavior prior to approach	No change	Change	Behavior during approach
Perching	111	4	preening
		1	aggression
		1	flight-in-canyon
		1	feeding
		5	incubating
		1	brooding
		11	relocation
		1	out-of-canyon
Preening	19	6	perching
		2	out-of-view
		1	incubating
		1	nest visit
		2	relocation
Patrolling	1	2	perching
Aggression	1	0	
Copulation	0	1	perching
		1	out-of-view
Flight-in-canyon	0	3	perching
		3	out-of-sight
		1	perched out-of-view
		2	incubating
		4	out-of-canyon
Out-of-view	75	4	perching
		1	flight-in-canyon
Feeding	1	1	perching
		1	relocation
Perched out-of-view	19	1	perching
		1	preening
		1	aggression
		3	relocation
Incubating	157	2	preening
		1	aggression
		2	flight-in-canyon
		2	out-of-canyon
Brooding	35	1	aggression
Relocation		3	perching
		2	preening
		1	incubating
		1	out-of-canyon
Out-of-canyon	278	2	perching
		1	perched out-of-view
		2	incubating

during the approach period. A higher rate of change would suggest a reaction of the falcons to an observer. I investigated this by examining the frequency distribution of observed behavioral changes of falcons per hour over the period March through July. This function fitted a Poisson distribution (χ^2=10.09, df=7, 0.10<P<0.25). Then, I calculated the expected number of behavioral changes during the average observer approach time to the blinds (6.5±3.8 min; N=425). The expected frequency of occurrence of 1 or more behavioral changes during the average approach time to a blind was 7.4%. The observed percentage change (19.1%) was within the 90% confidence interval for approach times (90% c.i. for approach times 6.5+6.2 min; 90% c.i. for expected percentage behavioral change 0%<P(e)<43%).

Observing from Within and Outside a Blind

With 1 exception, behaviors of the Priest Upper falcons did not differ when recorded from inside or outside the blinds for either afternoon or morning (Appendix V and VI). The exception was that in the morning, observers recorded significantly more occurrences of female feeding behaviors when outside the blind (F=4.33, df=1 and 14, P=0.05). Overall, we concluded that falcon behavior was not noticeably changed due to an observer sitting outside the blind at Priest Upper.

Productivity and Occupancy

Productivity was highest in Tick Basin (3.0±1.9 young/pair; Table 15); however productivity did not differ significantly between the Swan Falls and Tick Basin study locations (Wilcoxon 2-sample test Z=-0.76, P(|Z|>0.76)=0.44) or between the Dedication Overlook and Tick Basin study locations (Wilcoxon 2-sample test Z=-1.30, P(|Z|>1.30)=0.19). Likewise, productivity did not differ between the Swan Falls and Dedication Overlook study locations (Wilcoxon 2-sample test Z=0.26, P(Z>0.26)=0.78) (Table 15).

Overall productivity in the BOPA study locations declined significantly in 1986 compared to the 1984 and 1985 nesting seasons (2.0±1.9, 2.8±1.4, and 3.6±1.6 young/pair, respectively) (Kruskal-Wallis χ^2=7.54, df=2, P(χ^2>=7.54)=0.02). In 1986 productivity in the Swan Falls study location (1.8±2.1 young/pair; N=4) was similar to that in 1984 and 1985 (3.6±0.9 young/pair and 3.0±2.0 young/pair, respectively) (Kruskal-Wallis χ^2=2.95, df=2, P=0.22). In 1986 productivity in the Dedication Overlook study location (1.2±1.9 young/pair; N=5) was significantly lower than in 1985 (4.0±1.4 young/pair; N=7), and lower, but not significantly different from 1984 (2.2±1.5 young/pair; N=6) (Tukey-type nonparametric multiple comparison P<0.05). Tick Basin showed a slightly lower, but not significantly different productivity in 1986 (3.0±1.9 young/pair; N=5) than in 1985 (3.5±1.7 young/pair; N=4) (Wilcoxon 2-sample test Z=0.50, P(Z>0.50)=0.61).

Hatching dates did not differ among the 3 BOPA study locations in 1986 (Kruskal-Wallis χ^2=0.19, df=3, P(χ^2>0.19)=0.97), but were an average 13 days later than in 1984 and 1985 (Holthuijzen 1984, 1985).

Table 15. Productivity (young/pair) and breeding chronology of prairie falcons in the 4 study locations, 1986 nesting season.

Location	No. chicks	Hatching date	Julian hatching date
Swan Falls			
Swan Dam Road Turn	4	30 April	120
Swan Dam N Side	3	9 May	129
Falcon Flats Brown Rock[1]	0	15 June	166
Falcon Flats Fingers[1]	0	19 June	170
Mean	1.8±2.1		146±25
Dedication Overlook			
Camera	4	2 June	153
PF II	0	10 May	130
Dedication Site[1]	0	26 May	146
Halverson Upper Lake[1] [2]	0	9 May	129
Halverson Upper Lake[3]	0	-	-
Priest Upper	2	23 May	143
Mean	1.2±1.9		140±10
Tick Basin			
Tick I	3	5 June	156
Tick II	3	7 May	127
Tick III	5	5 May	125
Red Trail	4	15 May	135
San Sebastian Basin[1]	0	1 June	152
Mean	3.0±1.9		139±15
Reynolds Creek			
Reynolds Lower	2	12 May	132
Reynolds Upper Road	3	18 May	138
Reynolds Midcanyon Cup	2	16 May	136
Reynolds Midcanyon Pt	0	-	-
Upper Reynolds Downstream	5	11 May	131
Reynolds Upper West	0	27 May	147
Reynolds Exp Station	0	18 May	138
Reynolds Mouth	1	30 May	150
Mean	1.4±1.7		139±7
Overall	1.8±1.8		142±14

[1]Failed: projected hatch based on estimated start of incubation.
[2]First of 2 nesting attempts.
[3]Second of 2 nesting attempts.

In the Swan Falls study location 3 nesting territories were vacant (Balls Basin Powerline, Ferry, and Swan Dam Three Poles). Occupancy rate in the Swan Falls study location decreased to 57% from 71% in 1985 and 86% in 1984 (Appendix VII). Two late nesting pairs (Falcon Flats Fingers and Falcon Flats Brown Rock) failed. The nestlings of 1 pair (Falcon Flats Fingers) probably died when they were about 21 days old. The other pair abandoned the aerie shortly after the estimated hatching date. Inspection of the 2 aeries showed no signs of the cause of nestling mortality.

In the Dedication Overlook study location 6 of 8 nesting territories which were occupied each year from 1976 to 1978, were occupied in 1986 (Appendix VII). Occupancy rate of all traditional nesting territories in the Dedication Overlook study location was 58% as in 1984 and 1985 (Holthuijzen 1984, 1985). One pair (Dedication Site) failed during early incubation. This failure may have been related to the absence of the adult male 1 week prior to abandonment. Four 25-day-old young suddenly vanished from another aerie (PF II). Subsequent inspection of the aerie, which was inaccessible to mammalian predators, did not reveal any information about the possible fate of the young. Young can quickly disappear without a trace as was evidenced by the Priest Upper pair. Two healthy 30-day-old nestlings were present on 22 June. Personnel left the blind at 2200 and returned the next day at 0700 to band the young. They found only 1 nestling present. Extensive searching did not reveal any further information about the missing young. Bobcats (Felis rufus) were seen regularly in this area, but predation by bobcats was unlikely due to the inaccessibility of the aerie. Predation by great-horned owls (Bubo virginianus) seems the most plausible explanation, especially since the young disappeared during the night or early morning hours.

The Halverson Upper Lake falcons were the only nesting pair which made 2 nesting attempts. The female incubated on a stick nest on 5 April. One week later the stick nest was deserted. The pair used another aerie approximately 100 m from the former one on 26 April and appeared to be incubating. This aerie was abandoned 10-14 days later. The pair remained in the nesting territory until 14 June. One falcon was seen passing through the nesting territory on that date. Both aeries were inaccessible to mammals. The stick nest, however, was situated on an open ledge, and ledges generally have much higher predation rates than protected aeries (90% higher egg loss; Ogden and Hornocker 1977). The second aerie was located in a vertical crack, and predation appeared unlikely. Human activity near the Halverson Upper Lake aerie was high, but behaviors of the falcon pair did not differ from those of other pairs during the same nesting stage. The pair did not react to human activities at the bottom of the nesting cliff, but the falcons did react to people climbing on the cliff above the aerie.

In the Tick Basin study location 5 breeding pairs were found 1986. One pair in Tick Basin (San Sebastian Basin) failed shortly after hatching. Cause of failure could not be determined because we were not able to enter the cavity which was situated in an unstable cliff face.

All 4 nesting territories in Reynolds Creek which were exposed to blasting in 1985 were occupied, and 3 were successful. One nesting territory (Reynolds Midcanyon Point) was occupied in early spring but was subsequently vacated. In addition to the territories used in 1985, 4 nesting territories not found in 1985 were located (Reynolds Mouth, Upper Reynolds Downstream, Reynolds Upper West and Reynolds Experiment Station). Of these, 2 were successful (Reynolds Mouth and Upper Reynolds Downstream); the other 2 failed. Both aeries where failures occurred were inaccessible to mammalian predators, but I did not inspect them to determine the cause of failure. All additional territories located in 1986 were probably occupied in 1985 because falcons were observed in their general vicinity. The falcon pair at Reynolds Lower used a ledge near a favorite target shooting spot and probably were shot. Of their 2 nestlings, 1 starved and the other was removed for rehabilitation. Later, in the same area a golden eagle (Aquila chrysaetos) was found, apparently shot. Its head and talons had been removed (W. Eastland, pers. commun.).

Morphological Measurements and Weight of Nestlings

Thirty-seven nestlings were measured, weighed, and banded. Three nestlings were excluded from the analysis because they were either starving (Reynolds Lower nesting territory), too young (estimated 25 days old; Tick I), or too old (estimated 35 day old; Reynolds Midcanyon Cup). Weights of remaining nestlings, 14 males and 20 females as judged from their tarsal width, were not standardized for age since they were all about 29 days old.

Females were heavier and larger than males, except for wing chord and 7th primary length, which did not differ between the sexes (Table 16). Tarsus width and length were the best predictors for male weight (R^2=0.99). The best predictors of female weight were culmen depth, culmen width, and footpad length (R^2=0.99). Female weights did not differ among study locations (F=1.60, df=3 and 19, P=0.22). However, male weights in the Dedication Overlook study location were lower than in the 3 other study locations (Duncan's multiple range test P=0.05). Nestling weights of late broods were lower than those of early broods (306±115 g (N=2) and 471±48 g (N=5) for males; and 559±259 g (N=3) and 714±82 g (N=10) for females, respectively). In 1986, males weighed an average 477±92 g (N=14) and females 693±124 g (N=20) which is significantly lower than weights obtained in the BOPA from 1974 through 1984 for falcons of about the same age (males 575±48 g, N=30, and females 811±84 g, N=21; t=3.77, df=16, P<0.001 and t=3.55, df=33, P<0.001, respectively). Weights of nestlings hatched in 1977 were excluded because 1977 was a drought year and not comparable to other years (U.S. Dep. Inter. 1979).

Behaviors of Falcons during the Nesting Season

Behavioral Repertoire

The falcon's daily behavioral repertoire in 1986 was similar to that in 1984 and 1985 (Table 17). During the pre-incubation stage, the female spent a considerable part of the day time perched near the

Table 16. Weights (g) and morphological measurements (mm) of nestling male and female prairie falcons, 1986.

Variable	Males			Females			Sex Differences[1]		
	Mean	SD	N	Mean	SD	N	t[1]	Df	P
Weight	477	92	14	693	124	20	-5.51	32	<0.01
Tarsus length	59.3	2.2	7	68.4	4.0	7	-5.21	12	<0.01
Tarsus lateral width	6.2	0.4	14	7.9	0.5	19	-10.80	31	<0.01
Tarsus dorsal width	7.0	0.8	14	8.7	0.8	20	-6.13	32	<0.01
Wing chord length	183	22	14	192	19	20	-1.32	32	0.19
Seventh primary length	112	22	14	110	110	20	-0.31	32	<0.75
Culmen width	10.3	0.8	14	11.7	1.1	20	-4.11	32	<0.01
Culmen depth	13.1	0.7	14	14.9	0.7	20	-8.40	32	<0.01
Culmen length	16.1	1.4	14	18.5	1.5	20	-4.74	32	<0.01
Footpad length	74.1	6.0	14	86.4	8.2	20	-4.78	32	<0.01

[1])Test statistic to determine differences in weight or morphology between sexes.

Table 17. Behavioral time budget (behaviors expressed as percentages of total daily observation time) for male and female prairie falcons (13 pairs) during (A) pre-incubation, (B) incubation, (C) brood-rearing, and (D) post-failure. N refers to days of observation.

A. Pre-Incubation (N=43)

	Male			Female		
Behavior	Mean	SD	Range	Mean	SD	Range
Perching	11.3	10.3	0.0-47.3	44.5	18.7	0.8-83.3
Preening	2.1	3.4	0.0-15.1	3.7	3.7	0.0-18.2
In scrape	1.6	8.4	0.0-54.6	7.9	14.7	0.0-61.3
Flight-in-canyon	2.0	1.7	0.2-7.6	1.3	1.2	0.0- 4.9
Out-of-canyon	61.4	22.9	0.0-94.5	17.0	12.6	0.0-62.4
Out-of-view	8.9	10.2	0.0-53.9	4.0	8.3	0.0-41.7

B. Incubation (N=71)

	Male			Female		
Behavior	Mean	SD	Range	Mean	SD	Range
Perching	8.2	6.9	0.2-29.5	10.8	11.4	0.4-54.5
Preening	4.8	4.4	0.0-17.2	5.2	5.4	0.0-23.6
Incubating	30.7	15.1	0.0-66.5	60.2	15.2	26.5-91.2
Flight-in-canyon	1.4	1.0	0.0-5.0	1.0	0.7	0.0- 3.2
Out-of-canyon	37.1	15.9	0.0-69.7	11.9	7.9	0.0-39.1
Out-of-view	9.0	11.0	0.0-54.6	2.4	5.1	0.0-29.0

Table 17. (Continued)

C. Brood-rearing (N=40)

Behavior	Male			Female		
	Mean	SD	Range	Mean	SD	Range
Perching	11.2	11.6	0.0-54.0	23.6	14.5	1.8-56.0
Preening	3.3	4.4	0.0-24.7	4.6	4.3	0.0-17.6
Brooding	3.3	5.9	0.0-18.7	25.5	30.5	0.0-73.1
Flight-in-canyon	1.2	0.7	0.0-2.9	1.4	1.1	0.2- 6.1
Out-of-canyon	63.0	25.6	0.0-99.4	29.0	15.6	0.0-57.7
Out-of-view	10.1	25.7	0.0-100.0	2.0	3.8	0.0-14.8

D. Post-failure (N=14)

Behavior	Male			Female		
	Mean	SD	Range	Mean	SD	Range
Perching	10.4	10.4	0.0-33.7	26.6	22.1	0.0-64.2
Preening	3.4	4.4	0.0-13.3	4.9	4.5	0.0-12.6
In scrape	0.0	0.0	0.0- 0.0	0.3	0.1	0.0- 0.4
Flight-in-canyon	1.4	1.4	0.0- 5.0	1.3	0.7	0.2- 2.6
Out-of-canyon	43.2	20.2	0.0-97.3	42.9	25.1	0.0-80.7
Out-of-view	26.6	33.7	0.0-100.0	13.8	25.9	0.0-100.0

aerie (44.5%). The male falcon spent more than half the day out of the canyon (61.4%) and provided most of the prey for the female. Females left the canyon for only 17.0% of the day. The 1986 nesting season differed from the previous 2 years by a long pre-incubation period for 7 of 13 observed falcon pairs. In late March pair bonding of all except 1 pair (Falcon Flats Brown Rock) was firmly established, as evidenced by prey deliveries, copulations, and inspections of potential aeries by the pair. Two pairs, however, did not lay eggs until mid-May. For these pairs the pre-incubation stage lasted up to 50 days.

Copulations averaged 2 to 3 per day during pre-incubation, increased to 4 per day several days prior to (estimated) egg-laying, and then dropped off sharply (Fig. 3). The female was largely inactive several days prior to egg-laying. The female incubated an average of 60.2% of the day, and the male incubated for 30.7% (Table 17 B). The female was out of the canyon 11.9% of the day, and she perched and preened near the aerie 16.0% of the day. The male remained out of the canyon an average 37.1% of the day and perched near the aerie for 13.0% of the day. During the brood-rearing stage the males almost doubled the time out of the canyon (63.0%) and brooded on average only 3.3% of the day (Table 17 C). The females spent an average 25.5% of the day brooding and were out of the canyon for 29.0% of the day. Females also perched and preened for long periods near the aerie (28.2%).

On 92 of 94 days females were observed on the aerie at dusk (67 of 69 days and 25 of 25 days during incubation and brood-rearing, respectively). The male was sometimes observed roosting in the nesting territory, or otherwise flew out of view and was assumed to be roosting. Thus, in almost all instances the female probably incubated the eggs or brooded the small chicks during the night as was noted for the 1984 and 1985 nesting seasons (Holthuijzen 1984, 1985). Nestlings were an average of 13 days old (range= 7-20 days) when last brooded at dusk.

The behavior of a falcon pair after failure of a nesting attempt differed considerably from to either the incubation or brood-rearing stage (Table 17 D). The pair bond usually dissolved quickly after failure of a nesting attempt, particularly when failure took place during brood-rearing (1-2 weeks; Falcon Flats Fingers, Falcon Flats Brown Rock, San Sebastian Basin, and PF II). The Halverson Upper Lake pair copulated up to 28 days after the 2nd nest attempt failed. The last observed prey delivery from the male to the female was 14 days after failure. Both sexes of this pair spent more than half the day away from the nesting territory (60.7±21.6% and 52.0±31.8% of the day for male and female, respectively). The pair was present in the nesting territory until 35 days after failure. On the 35th day the male brought in prey cached it. The female was never observed on the 35th day. Females spent more time in the nesting territory than males (31.5 and 13.8% of the day) after failure took place and inspected new aeries. Collectively, both sexes were out of the canyon or out of view for a large percentage of the day (69.8 and 56.7% for males and females, respectively).

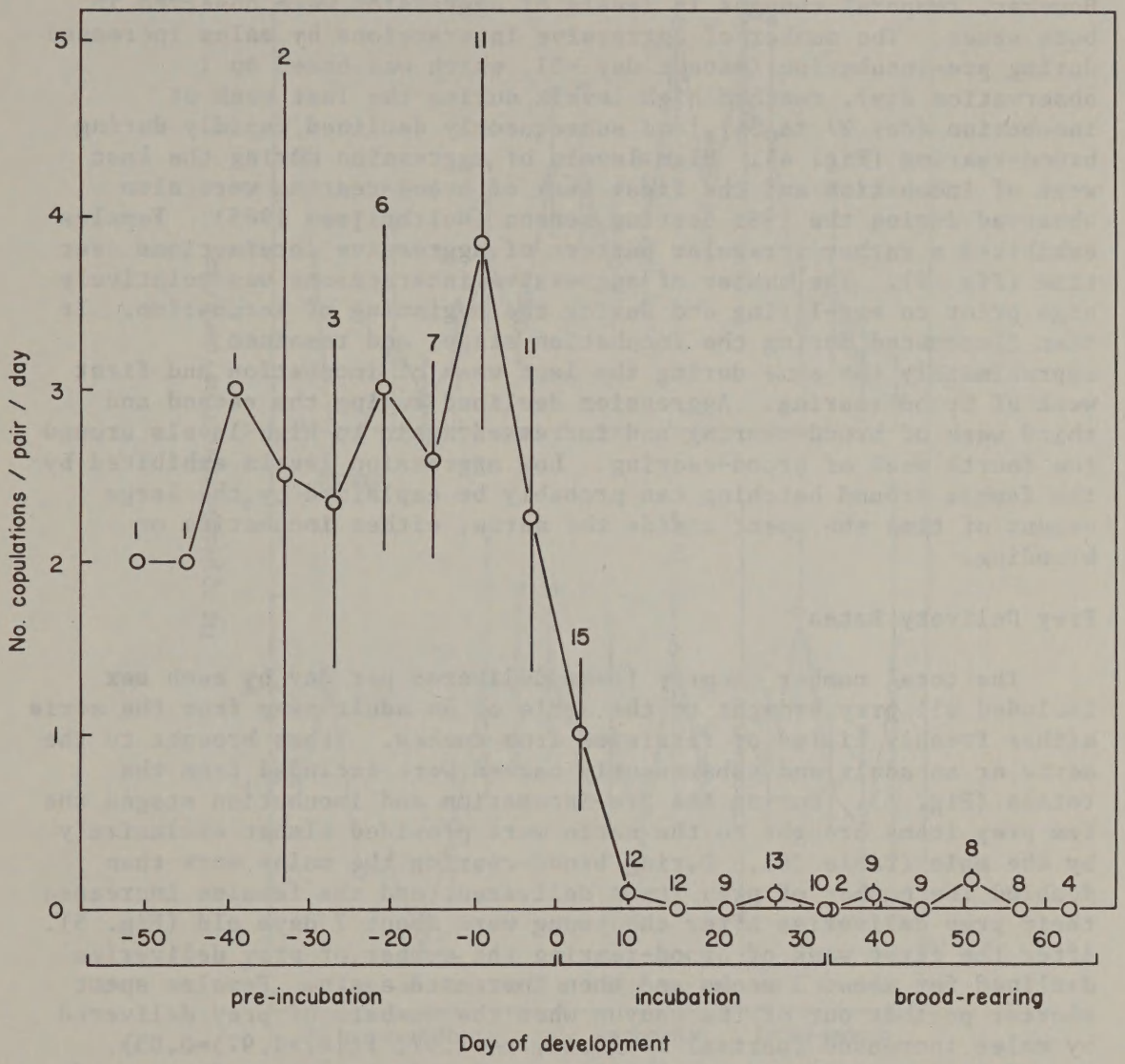

Fig. 3. Numbers of copulations per prairie falcon pair per day during the 1986 nesting season.

Aggression

The number of aggressive interactions was influenced by nesting stage and nesting pair (ANOVA, $F=2.31$, $df=3$ and 317, $P=0.07$; and $F=7.03$, $df=12$ and 317, $P<0.01$), but not by study location or sex ($F=0.50$, $df=2$ and 317, $P=0.60$; and $F=0.62$, $df=1$ and 317, $P=0.43$). However, temporal changes in levels of aggression were observed in both sexes. The number of aggressive interactions by males increased during pre-incubation (except day -51, which was based on 1 observation day), reached high levels during the last week of incubation (day 27 to 34), and subsequently declined rapidly during brood-rearing (Fig. 4). High levels of aggression during the last week of incubation and the first week of brood-rearing were also observed during the 1985 nesting season (Holthuijzen 1985). Females exhibited a rather irregular pattern of aggressive interactions over time (Fig. 4). The number of aggressive interactions was relatively high prior to egg-laying and during the beginning of incubation. It then fluctuated during the incubation stage, and remained approximately the same during the last week of incubation and first week of brood-rearing. Aggression declined during the second and third week of brood-rearing and increased again to high levels around the fourth week of brood-rearing. Low aggression levels exhibited by the female around hatching can probably be explained by the large amount of time she spent inside the aerie, either incubating or brooding.

Prey Delivery Rates

The total number of prey items delivered per day by each sex included all prey brought to the aerie or an adult away from the aerie either freshly killed or retrieved from caches. Items brought to the aerie or an adult and subsequently cached were excluded from the totals (Fig. 5). During the pre-incubation and incubation stages the few prey items brought to the aerie were provided almost exclusively by the male (Table 18). During brood-rearing the males more than doubled the number of prey items delivered, and the females increased their prey deliveries after the young were about 7 days old (Fig. 5). After the first week of brood-rearing the number of prey deliveries declined for about 2 weeks and then increased again. Females spent shorter periods out of the canyon when the numbers of prey delivered by males increased (partial $b=-13.56$, $t=-1.97$, $P(|t|>1.97)=0.05$). Prey delivery rates did not differ among study locations for any of the 3 nesting stages (pre-incubation: $F=1.69$, $df=2$ and 37, $P=0.19$; incubation: $F=0.03$, $df=2$ and 66, $P=0.97$; and brood-rearing: $F=1.16$, $df=2$ and 37, $P=0.32$). The average number of prey items delivered per day did not increase with brood size, as estimated when nestlings were 21 days and older (partial $b=0.11$, $t=0.53$, $P(t>0.53)=0.60$), nor with average nestling-age (partial $b=0.02$, $t=0.61$, $P(t>0.54)$ for all pairs combined.

The number of prey items delivered to the aerie for all pairs combined during brood-rearing in 1986 (4.3±2.2) was significantly lower than in 1985 (6.0±2.7) ($F=61.96$, $df=1$ and 246, $P=0.0001$). This was mainly due to low prey deliveries during the 2nd and 3rd weeks of

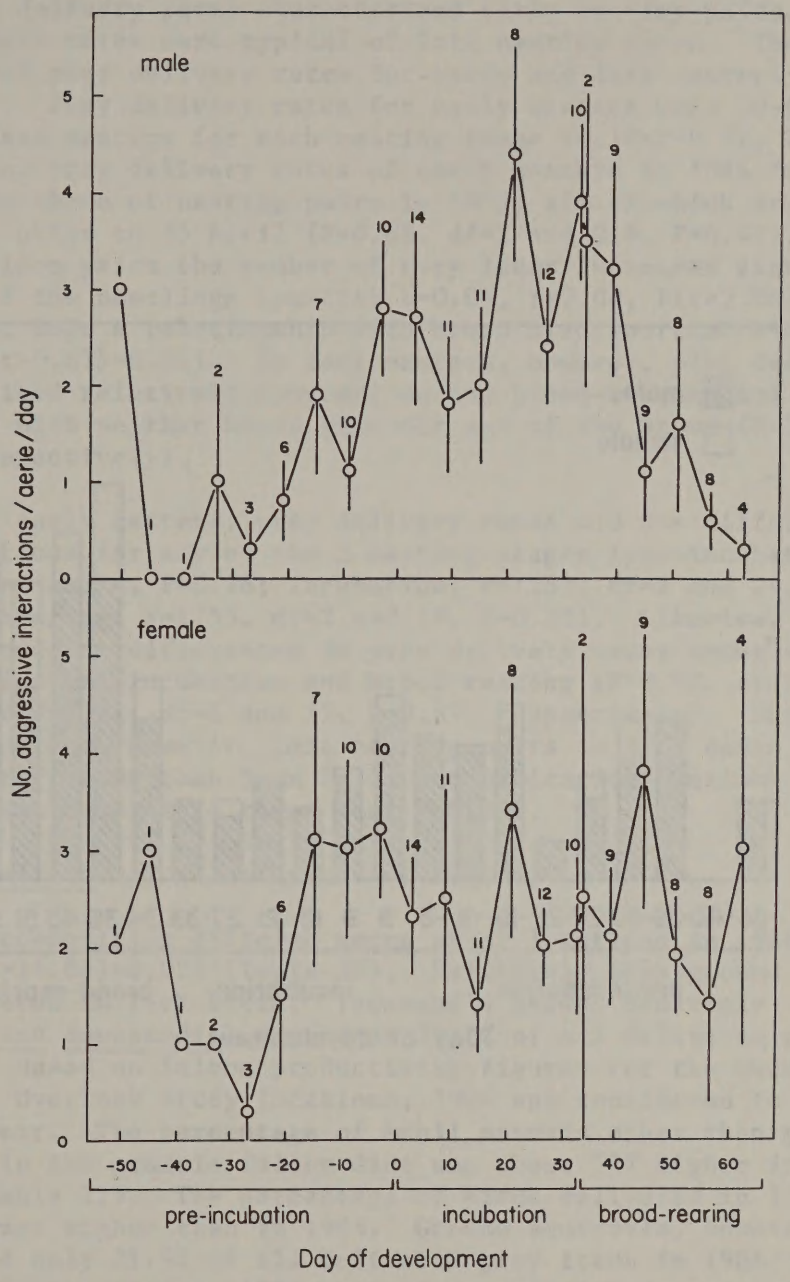

Fig. 4. Numbers of aggressive interactions per prairie falcon pair per day during the 1986 nesting season.

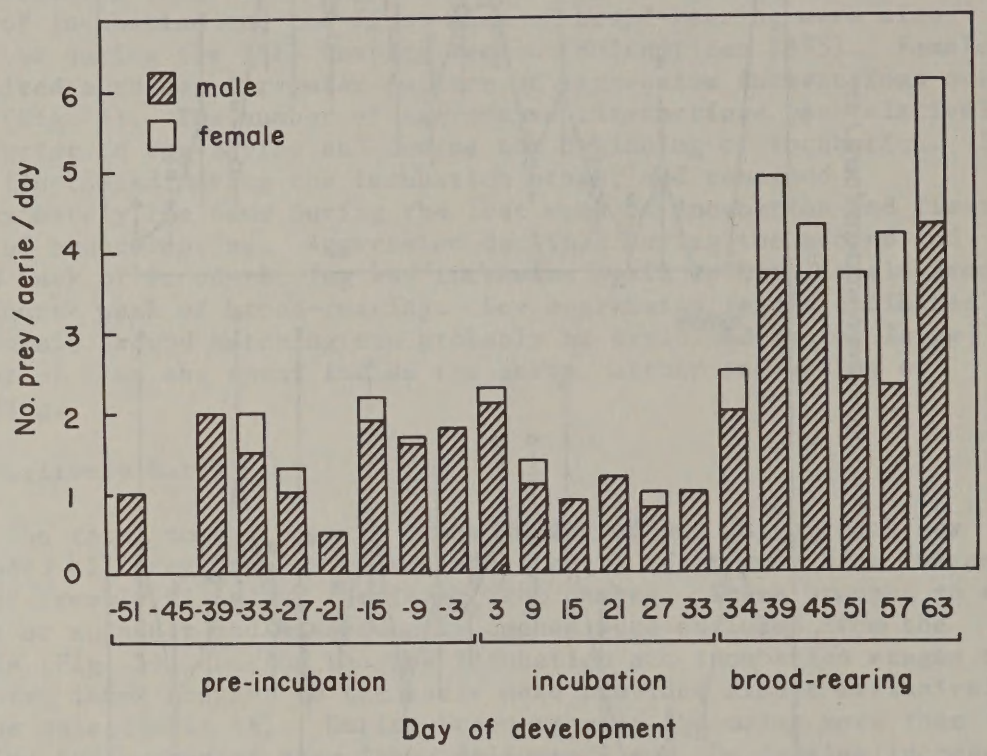

Fig. 5. Numbers of prey items delivered to the nesting territory per prairie falcon pair per day during the 1986 nesting season.

brood-rearing. Prey delivery rates during pre-incubation and date of clutch initiation were inversely correlated ($r=-0.31$, $P=0.04$, $N=42$), i.e., high delivery rates characterized early nesting pairs, and low prey delivery rates were typical of late nesting pairs. Therefore, we investigated prey delivery rates for early and late nesters separately. Prey delivery rates for early nesters were 50-60% higher than for late nesters for each nesting stage ($0.10<P<0.01$; Table 19). Furthermore, prey delivery rates of early nesters in 1986 did not differ from those of nesting pairs in 1985, all of which started incubation prior to 15 April ($F=0.68$, $df=1$ and 219, $P=0.41$). In early nesting falcon pairs the number of prey items increased significantly with age of the nestlings (partial $b=0.09$, $t=2.08$, $P(t>2.08)=0.05$), but did not show a relationship with brood size (partial $b=0.15$, $t=0.67$, $P(t>0.67)=0.51$). In late nesters, however, prey delivery rates remained relatively constant during brood-rearing and were associated with neither brood size nor age of the brood ($P=0.41$ and $P=0.30$, respectively).

Among early nesters, prey delivery rates did not differ among study locations for any of the 3 nesting stages (pre-incubation: $F=1.86$, $df=2$ and 4, $P=0.26$; incubation: $F=1.83$, $df=2$ and 29, $P=0.17$; and brood-rearing: $F=1.55$, $df=2$ and 19, $P=0.23$). Likewise, late nesters showed no differences in prey delivery rates among study locations for pre-incubation and brood-rearing ($F=0.97$, $df=2$ and 30, $P=0.39$; and $F=0.11$, $df=2$ and 15, $P=0.89$, respectively). During the incubation stage, however, late nesting pairs in Tick Basin had lower prey delivery rates than Swan Falls and Dedication Overlook falcon pairs (Duncan's multiple range test $P=0.05$).

Diet Composition

Diet composition differed among study locations in 1986 ($\chi^2=14.84$, $df=6$, $P(\chi^2>14.84)=0.02$) (Table 20). Relatively more ground squirrels were delivered in Tick Basin. Townsend's ground squirrels (*Spermophilus townsendii*) comprised 21.9% of all delivered prey items combined. Based on falcon productivity figures for the Swan Falls and Dedication Overlook study locations, 1984 was considered to be a "normal" year. The percentage of small mammals other than ground squirrels in the prairie falcon diet was about 50% higher in 1986 than in 1984 (Table 21). The percentage of birds delivered in 1986 was about 3 times higher than in 1984. Ground squirrels, however, represented only 21.9% of all delivered prey items in 1986, a decrease of about 40% compared to 1984, assuming a similar accuracy in identifying prey species for the 2 nesting seasons. Ground squirrels are relatively large prey items, and can usually be identified without problems, except when repeatedly retrieved, fed on, and cached. The data suggest an apparent decline in numbers of ground squirrels delivered to the aeries in 1986, which may have been compensated by an increase in birds and small mammals other than ground squirrels. The large percentage of unidentified prey items and small mammals other than ground squirrels in 1984 and 1986, however, makes interpretation of these data somewhat speculative.

Table 18. Numbers of prey items delivered to the aerie or to an adult, cached, and retrieved per day by prairie falcon pairs, 1986 nesting season.

	Pre-incubation				Incubation				Brood-rearing			
	Male		Female		Male		Female		Male		Female	
Prey	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Delivered	1.4	1.3	0.1	0.2	1.1	1.1	0.1	0.3	2.9	2.1	1.1	1.0
Cached	0.1	0.3	0.2	0.4	0.1	0.4	0.3	0.5	0.1	0.4	1.1	1.1
Retrieved	0.1	0.4	0.2	0.5	0.2	0.6	0.3	0.5	0.4	0.8	1.2	1.4
Delivered by male and female	1.5±1.3 (N=42)				1.3±1.2 (N=72)				4.3±2.2 (N=40)			

Table 19. Numbers of prey items delivered to the aerie or to an adult, cached, and retrieved per day by prairie falcon pairs incubating (A) before 15 April, and (B) after 15 April 1986.

A. Before 15 April (early nesters)

	Pre-incubation				Incubation				Brood-rearing			
	Male		Female		Male		Female		Male		Female	
Prey	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Delivered	2.3	1.4	0.0	0.0	1.7	1.1	0.1	0.3	4.0	1.8	1.2	1.3
Cached	0.0	0.0	0.3	0.5	0.3	0.6	0.3	0.5	0.3	0.6	1.0	1.0
Retrieved	0.1	0.4	0.3	0.8	0.3	0.7	0.2	0.5	0.5	1.0	0.9	1.1
Delivered by male and female	2.4±1.3 (N=7)				1.7±1.3 (N=32)				5.3±1.9 (N=22)			

B. After 15 April (late nesters)

	Pre-incubation				Incubation				Brood-rearing			
	Male		Female		Male		Female		Male		Female	
Prey category	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Delivered	1.2	1.1	0.1	0.2	0.6	0.8	0.1	0.3	1.6	1.7	1.1	0.6
Cached	0.2	0.4	0.2	0.4	0.0	0.0	0.1	0.3	0.0	0.0	1.2	1.2
Retrieved	0.2	0.4	0.2	0.5	0.1	0.3	0.2	0.5	0.2	0.4	1.6	1.7
Delivered by male and female	1.2±1.1 (N=33)				0.9±0.8 (N=37)				3.2±2.0 (N=18)			

Table 20. Types of prey items delivered to the aerie by prairie falcons in each of the 3 BOPA study locations, 1986 nesting season. Numbers in parentheses are percentages of total number of prey items delivered in each of the study locations.

Study location	Prey category				
	Bird	Ground squirrel	Small mammal	Unidentified	Total
Swan Falls	5 (4.6)	18 (16.5)	37 (33.9)	49 (45.0)	109
Dedication Overlook	5 (5.0)	20 (19.8)	44 (43.6)	32 (31.7)	101
Tick Basin	13 (10.2)	36 (28.1)	34 (26.6)	45 (35.2)	128
Total	23 (6.8)	74 (21.9)	115 (34.0)	126 (37.3)	338

Table 21. Types of prey items delivered to the aerie by prairie falcons, nesting seasons 1984 and 1986. Numbers in parentheses are percentages of total number of prey items delivered by male, female falcon, or year.

Sex	Prey category				
	Bird	Ground squirrel	Small mammal	Unidentified	Total
Male	22 (7.8)	57 (20.1)	105 (37.1)	99 (35.0)	283
Female	1 (1.8)	17 (30.9)	10 (18.2)	27 (49.1)	55
1986 Total	23 (6.8)	74 (21.9)	115 (34.0)	126 (37.3)	338
1984	6 (2.0)	109 (35.8)	55 (18.1)	134 (44.1)	304

The gradual estivation of male, female, and juvenile ground squirrels from May to July results in a declining food supply available to late nesting prairie falcons (U.S. Dep. Inter. 1979). Under these circumstances a shift may be expected in diet composition between late and early nesting falcons. However, such a shift was not observed (χ^2=7.70, df=3, P=0.05). Prey composition differed mainly in higher than expected deliveries of unknown prey items in late nesters. Higher numbers of unidentified prey items may suggest an increase in smaller prey items delivered.

DISCUSSION AND CONCLUSIONS

Human Activity in the BOPA

The distribution of visitors in 1986 was somewhat different than in 1985. A larger percentage of vehicles entering the Swan Falls area moved upstream in 1986 than in 1985 (6 and 4%, respectively). About 15% of vehicles moved downstream in 1986 as compared to an average 8% in 1985. In 1986 77% of these vehicles continued downstream into BLM land (81.7% in 1985) and 47% passed Priest Rapids (30.5% in 1985). Thus, a larger percentage of visitors moved farther downstream in 1986 than in 1985. This may have been caused in part by construction at Swan Falls dam which restricted access to the river for fishing, and high water levels which had a negative impact on fishing success (S. Addington, pers. commun.). Principal recreation activities were fishing and sightseeing (46.6%; Table 2). Recreational activities were concentrated along the roads running parallel to the river. Since sightseeing was listed as a 2nd principal activity by 70% of the fishermen signing the registration box (S. Addington, pers. commun.), poor fishing conditions may have induced fishermen to explore more of the canyon. The total number of people entering the BOPA from March through June, excluding residential and construction traffic, was estimated at 7,000 in 1986 and 8,000 in 1985. Thus, estimated use levels in 1986 dropped 13% compared to 1985. This decrease appeared to be related to wet spring weekend weather (S. Addington, pers. commun.).

In contrast to 1984 and 1985, heavy construction took place throughout the nesting season in 1986. These activities centered around the dam, the west side of the river and an island 200 m downstream where construction materials were stockpiled (Fig. 2).

Effects of Human Activity

Associations between Human Activity and Falcon Behavior

Several prairie falcon behaviors were associated with human activity variables. Preening, aggression, prey delivery, and feeding behavior were positively associated with "traffic" and negatively with "people" (Tables 8 and 9). Also, the variables "people" and "traffic" exhibited an inverse relationship. The observed associations are more likely to be artifacts of visitor use patterns at Swan Falls combined with the behavior patterns of prairie falcons during the nesting season. This can be explained as follows. The 2 successful pairs at

Swan Falls nested early and had relatively high prey delivery rates. In contrast, the only successful pair in the Dedication Overlook study location (Camera) bred late and had relatively low prey delivery rates (Tables 19 A & B). Traffic flows were high at Swan Falls and consisted mostly of construction and residential traffic; in contrast, visitor use was low (Table 6). At Dedication Overlook, however, traffic flows were low, but visitor use was high. Thus, traffic flows measured at Swan Falls and Dedication Overlook were negatively associated with visitor use and positively with prey delivery rates. Therefore, we conclude that associations between human activity and behavioral variables such as prey delivery, are coincidental and are not an expression of human activities influencing falcon behavior. Behavioral repertoires in each of 3 stages of the nesting season for falcons nesting in the construction and recreation study locations did not show significant differences with falcon pairs nesting in the control study location, further supporting the above conclusion.

Associations between Human Activity and Nestling Weight

Human activity apparently did not affect the physical condition of female prairie falcon nestlings, which had similar weights in each of the study locations. Male nestling weights, however, were lower in Dedication Overlook than in the other 2 study locations. Male weights in the Dedication Overlook study location were collected from only 1 late nesting pair (Camera) which had low prey delivery rates.

Blasting Effects

The average readjustment time of falcons to blasting in the Swan Falls study location was longer, but not significantly different from the readjustment time of falcons exposed to experimental blasting in 1985 (2.64±3.71 min (N=14) and 1.86±3.20 min (N=180), respectively; $0.20<P<0.50$). Differences in readjustment times may be attributed to the small sample size at Swan Falls, but other factors may also be involved. The charges used at Swan Falls Dam were many times larger than at Reynolds Creek. Each construction blast involved several hundred pounds of high explosives. Blasts were conducted underground or in the old spillway structure. Thus the nature of the blast at Swan Falls was different from the experimental blasts at Reynolds Creek. Sound levels were measured but are not available to be included in the analysis. Without an analysis of the sound measurements it is unclear how comparable the blasting events at Reynolds Creek and Swan Falls were. Although the blasts were much more powerful at Swan Falls than at Reynolds Creek, the exposed falcon aeries were much further removed from the blasting location ($\bar{x}$=810 m; range=560-1000 m) than the aeries at Reynolds Creek ($\bar{x}$=127 m; Holthuijzen 1985). Average readjustment time did not differ among breeding stages at Swan Falls. This differs from Reynolds Creek where a decrease was observed over time (Holthuijzen 1985). Behavioral reactions of falcons to blasting at Swan Falls were similar to reactions observed at Reynolds Creek. Incubating birds generally continued incubating, and brooding falcons showed no visible reaction.

Blasting at Swan Falls began when 2 pairs had just started incubation (Swan Dam Road Turn and Swan Road N. Side). Both pairs successfully raised young. The remaining 2 pairs (Falcon Flats Fingers and Falcon Flats Brown Rock) were exposed to blasting during most of the pre-incubation stage and probably during egg-laying. However, these falcons were often out of the canyon and were thus not exposed to all blasts. Both pairs were late nesters and both failed in their nesting attempt. Late nesting does not seem to be related to blasting because late nesting pairs were found in all 3 BOPA study locations. Late nesters also showed poor reproduction in the other 2 study locations. The behavioral repertoire of all Swan Falls pairs exposed to blasting was similar to the control pairs in Tick Basin.

Several investigators (e.g., Fyfe and Olendorff 1976, Harmata et al. 1978) reported that nesting prairie falcons were disturbed by slamming doors of vehicles 100-150 m from the aerie. They suggested that extended periods of such activities may even cause desertion. Our observations on falcons exposed to experimental and construction blasting suggested considerable resilience to high sound levels. Falcons in Reynolds Creek, however, reacted more frequently (124 out 186 blasts; 66.7%) to blasting than pairs in Swan Falls (14 out 68 blasts; 20.6%) (χ^2=40.77, df=1, $P(\chi^2>40.77)<<0.001$). Reynolds Creek is difficult to access, even by foot. Cattle ranching is the main human activity. Prairie falcons show a tendency to return to the same general area where they were hatched (Steenhof et al. 1984, Runde 1987). Thus, habituation to high levels of human activity by falcons nesting in Reynolds Creek was not likely to have taken place in the recent past. In contrast, falcons nesting at Swan Falls may have been exposed to at least some human activities as nestlings or fledglings. Perhaps falcons nesting in Reynolds Creek were more easily disturbed because of their supposed low level of exposure to human activities, as was found for other raptors nesting in remote areas (Newton 1979).

The responses of raptors to human activities vary among species and geographical areas, as well as among individuals (Newton 1979, Fraser 1984). Some individuals tolerate high levels of disturbance, as exhibited by a pair of prairie falcons exposed to coal mining activities that included blasting and operation of heavy equipment within 75 m of the aerie (Platt cited in Bednarz 1984). Peregrine falcons (Falco peregrinus) nested successfully near active excavation areas where blasting occurred regularly (Pruett-Jones et al. 1980, Haugh 1982). Ferruginous hawks (Buteo regalis), in contrast, were very sensitive to simulated sound levels and in some cases abandoned their nests (White and Thurow 1985). Our study shows that neither experimental nor industrial blasting had such dramatic effects on prairie falcons.

Observer Effects

Observers approaching or leaving blinds did not elicit a higher than expected percentage change in falcon behavior, and blind distance was unrelated to the frequency of behavioral changes. In other studies nesting prairie falcons were sometimes observed from only 2 m from the aerie (Sitter 1983) or were exposed to visits by researchers climbing to

nests (Steenhof and Kochert 1982). Peterson and Stewart (1976) suggested that human actvities well below an aerie elicited little or no reponse from nesting prairie falcons. These studies suggest considerable tolerance of nesting falcons to human activity, without an effect on reproductive success. In this study, blinds were placed below the aeries at distances of 95 to 190 m from the aeries. This also constituted the minimum distance between observers and the aerie. The lack of a significant response of prairie falcons to observers approaching or leaving blinds is in agreement with the observed tolerance of prairie falcons to considerable levels of human activity as discussed above.

I found no appreciable difference between behavioral observations collected from within or outside of a blind. Apparently the falcons did not react to the presence of an observer, whether this person was in or outside of a blind. Thus, it is likely that qualitatively similar results would be collected from within or from outside of a blind. Summarizing, I conclude that (1) our observation procedures apparently did not affect falcon behavior, and (2) behavioral observations made from within and from outside a blind are comparable.

Effects of Human Activity on Productivity and Occupancy

Four of 7 traditional nesting territories in the Swan Falls study location are situated along the Swan Falls access road (Appendix V). Four nesting territories along the Swan Falls access road were occupied in 1976, and 3 were occupied in 1977 and 1978. Three nesting territories along Swan Falls road were occupied in 1984, and 2 in both 1985 and 1986. Thus, the effects of road construction and subsequent increased traffic flows on prairie falcon occupancy of nesting territories along Swan Falls road are still unclear.

In 1986 average productivity in the 3 BOPA study locations was significantly lower than in 1984 and 1985. Six of 13 observed pairs failed their nesting attempt. This is in sharp contrast with the failure rates of the 1984 and 1985 nesting seasons, when only 1 of 20 observed pairs failed. Two pairs (Falcon Flats Fingers and Falcon Flats Brown Rock) had hatching dates later than 12 June. Only 8 of 514 recorded nesting attempts over an 11-year study period at the BOPA had hatching dates of 12 June or later (Allen et al. 1986). Although our sample size is small, the high failure rate and late incubation date of the observed falcon pairs in the BOPA (averaging 2 weeks later than 1984 and 1985) suggests that some factor affected prairie falcon reproduction in 1986.

Nesting raptors disturbed during the nesting season may successfully raise young, but may not re-occupy the same nesting territory in subsequent years (Fyfe and Olendorff 1976, Platt 1977, Ratcliffe 1980, White and Thurow 1985). Potentially disruptive human activity over several nesting seasons may reduce raptor nesting densities (Waardenburg 1976, 1977, Hennessy 1978, Craighead and Mindell 1981, Boyce 1982). In the above studies raptor productivity or occupancy of nesting territories was correlated with human activities. Conclusions are thus based on statistical inference, and evidence of cause-effect releationships is circumstantial. Factors

other than human activity should also be taken into consideration to determine which factor or combination of factors may have induced an observed decline in nesting raptors. Prey abundance and availability in particular may compensate for the effects of disturbance by positively affecting the condition of adult birds, their ability to procure prey, and therefore the survival of their young (Van der Zande and Verstrael 1985, White and Thurow 1985, Newton 1980, 1986). Abundance of prey and absence of direct persecution can induce settlement of areas of high human activity as demonstrated by the occupation of cities by peregrine falcons, European sparrowhawks (Accipiter nisus), European kestrels (Falco tinnunculus), hobbies (Falco subbuteo) and merlins (Falco columbarius) (Ratcliffe 1980, Newton 1979, 1986). The prey base appears to be the ultimate factor determining population densities, which are further modified by proximate factors (e.g., breeding cavities) (Newton 1979, 1980). These observations may also apply to prairie falcons. Prairie falcon nesting chronology in the BOPA is strongly synchronized with the life cycle of the Townsend's ground squirrel (U.S. Dep. Inter. 1979). Furthermore, productivity and nesting densities of the prairie falcon in the BOPA appear to be strongly related to ground squirrel densities (U.S. Dep. Inter. 1979).

Breeding Biology of Prairie Falcons

Behaviors of Falcons During the Nesting Season

The behavioral repertoire of female prairie falcons during the 1986 nesting season (Table 17) was similar to behaviors observed in 1984 and 1985 (Holthuijzen 1984, 1985). Females were largely inactive during the pre-incubation stage and spent up to 60% of the day perched near the aerie, preening, or out-of-view inside the aerie. This has been referred to as pre-laying lethargy (Newton 1979). The number of copulations per day ($\bar{x}$=3, range=0-11; N=22) peaked before egg-laying, then rapidly decreased during the first week of incubation. A small number of copulations took place during incubation and brood-rearing (Fig. 4). Copulation timing and sequence of prairie falcons appear to be similar to that of peregrine falcons. In most peregrine falcon pairs copulations increased to a maximum a week before laying, continued until the third egg was laid and some took place after the clutch was completed (Ratcliffe 1980).

Female prairie falcons incubated an average of 60.2% of the day and males 30.7%. This is similar to estimates for wild peregrine falcon males (30-50% at mid-incubation) and captive nesting male peregrine falcons (Ratcliffe 1980). Like peregrine falcons, female prairie falcons usually incubated during the night (Ratcliffe 1980). The female brooded most of the day ($\bar{x}$=25.5% ; range 0-73.1%). Males generally brooded for short periods ($\bar{x}$=3.3% of the day; range=0-18.7%). Males may be less inclined to brood because, like male peregrine falcons, they are too small to adequately cover the nestlings (Ratcliffe 1980, Hovis et al. 1985). Brooding declined rapidly over time. After nestlings were 14 days old, they were generally not brooded during the day.

I assumed that falcons were most likely involved in hunting when they were outside the canyon. The amount of time spent outside the canyon by falcons in this study agrees well with estimates from time budgets established by radio tracking prairie falcons in the BOPA (Dunstan et al. 1976). The number of prey items delivered to the aerie by the male increased during brood-rearing, and both males and females spent a larger percentage of the day away from the canyon.

The number of aggressive interactions by males increased during pre-incubation and incubation and rapidly declined during brood-rearing. This change was probably due to the male spending increasingly longer periods of time out of the canyon to provide food for both the young and the female. Females showed an irregular pattern with low levels of aggressive interaction around the hatching date. These observations are not in agreement with Sitter's (1983) observation that aggression decreased over the nesting season, only to peak when young fledged. Two hypotheses have been proposed to explain temporal changes in the intensity of nest defense. The first hypothesis predicts an increase in nest defense as the young near fledging because of the increasingly larger investment the parents have made in their offspring. Alternatively, older nestlings may be more conspicuous, which would neccessitate an increase in nest defense to avoid predation (Knight and Temple 1986). The female falcon broods the young until they can thermoregulate, and then she gradually starts hunting. Hunting by the female is probably important in supplying sufficient food to satisfy the increasing energetic demands of the rapidly growing young. It is probably a favorable trade-off in exchange for her continued presence near the aerie to defend the nestlings against predators. Towards the end of the brood-rearing stage adult falcons were often absent from the nesting territory. Brood size was positively correlated with time adults spent out of the canyon (Holthuijzen 1985). Aggressive behavior is also subject to strong individual variation (Holthuijzen 1984, 1985). All these factors may potentially confound a temporal trend in aggressive behavior over the nesting season. Currently, not all aggression data have been automated, and a full evaluation of the 2 hypotheses mentioned above is not yet possible.

Factors Influencing Nesting Chronology and Success

Laying date of several species of raptors has been found to be affected by: (1) condition of the female when arriving at the breeding grounds, (2) ability of the male to provide prey to the female, and (3) prey abundance (Newton 1979). I have no information on the condition of female falcons when they arrived at our study area. During pre-incubation (pre-laying) the female falcon depends largely on the male for sufficient prey. She needs extra food for breeding, not only to produce the eggs, but also to accumulate large enough body reserves for incubation and brood-rearing (Newton 1979, 1980). Therefore, the ability of the male to provide enough food may be critical in determining laying date. In both late and early nesting pairs males provided almost all prey during pre-incubation (Tables 19 A & B). The percentage of the day males spent outside the canyon, presumably hunting, was only slightly higher for early nesting males

(70.3%) than late nesting males (59.7%). Early nesting males, however, provided twice as much prey than late nesting males. All males probably hunted north of the river and probably had overlapping home ranges as was found in telemetry studies (Dunstan et al. 1976). Thus, the hunting area used by the prairie falcons may have been of similar quality with respect to prey. If this assumption is correct early nesting males may have been more proficient hunters than late nesting males. Inability of the male to provide sufficient food to the females may have induced the female to hunt for herself. This is suggested by the larger amount of time spent out of the canyon during pre-incubation by late nesting females compared to early nesting females (20.8% versus 3.6%, respectively).

Prey delivery rates for late nesting falcons during the pre-incubation and incubation stages in 1986 were similar to prey delivery rates in 1985, when prairie falcons showed normal reproduction (Holthuijzen 1985). Apparently, even though delivery rates were similar, in 1986 they were insufficient to induce early nesting. I hypothesize that laying date in prairie falcons may be determined by the condition of the female prior to egg-laying and the proficiency of males in providing prey during pre-incubation. Our prey delivery rate data suggest that more proficient males were associated with early nesting. Similar observations were made in several other raptorial birds (e.g., European sparrowhawk; Newton 1986) as well as non-raptorial birds (Newton 1979, 1980).

Townsend's ground squirrel numbers were not directly estimated in 1986. However, a 56% decline in active Townsend's ground squirrel burrows was found in 1986 compared to 1982 (Peterson and Yensen 1986). Since the number of active burrows is significantly correlated with ground squirrel density (Nydegger and Smith 1986) it is possible that a decrease in ground squirrel density may have occurred. It is not known, however, in what year or over what period this apparent decline may have occurred. The apparent decline in ground squirrel densities may be associated with a loss of about 50% of the shrub cover in the BOPA to range fires over the past years (Nydegger and Smith 1986, BLM, unpubl. data).

The breeding cycle of the prairie falcon in the BOPA is highly synchronized with the annual cycle of their principal prey species, the Townsend's ground squirrel (U.S. Dep. Inter. 1979). The breeding cycle of late nesting pairs was asynchronous with Townsend's ground squirrel numbers. Late nesting pairs faced declining ground squirrel numbers because of the gradual estivation of male, female, and juvenile ground squirrels from May through July. Possible low ground squirrel numbers in 1986 may have aggravated the situation. Late nesting falcons showed much lower prey delivery rates than early nesting falcons during incubation and brood-rearing. The effect of these low prey delivery rates also was suggested by the low weights of nestlings of late broods. Although some late nesting pairs produced fledglings, survival of these falcons is doubtful because prey is likely to be scarce in July and probably difficult to obtain by the inexperienced fledglings which were also in poor condition.

In 1977, when Townsend's ground squirrels decreased to low numbers, prairie falcons shifted to alternate prey species, particularly birds (U.S. Dep. Inter. 1979). In 1986 a similar shift, though not as pronounced, in diet composition appeared to have occurred. This shift may be related to an apparent decline in Townsend's ground squirrel numbers. I emphasize that the above discussion is based largely on circumstantial data collected on a small number of observed nesting prairie falcon pairs in the BOPA.

The 1986 data underscore the need to consider the impact of human activities on behavior and productivity of prairie falcons in the broader context of other ecological factors. Assessing the relative magnitude of major ecological factors affecting the prairie falcon population in the BOPA is of particular importance. Insight is currently limited by the incomplete knowledge of ecological factors influencing raptor productivity in the BOPA. Continued monitoring of raptor, and prey populations and vegetational changes in the BOPA is essential to provide an explanation for population fluctuations of raptors and for informed management decisions.

FUTURE RESEARCH AND RECOMMENDATIONS

Construction at Swan Falls Dam was completed in December 1986. The behavior and productivity of nesting falcons in the Swan Falls study location will be monitored through 1987 to determine long-term effects of the construction on nesting prairie falcons. Productivity and occupancy figures for the 1987 nesting season are important particularly after the poor reproduction shown in the 1986 nesting season. Recreational use of the Swan Falls area increased in 1984 and 1985, but declined in 1986. Access into the canyon has been improved by construction of the Swan Falls access road in 1984. I will continue monitoring the effects of recreation and research activities of this study on nesting falcons in 1987.

All prairie falcon pairs in the Swan Falls, Dedication Overlook, and Tick Basin study locations will be used for observations. Occupancy and productivity of all aeries in the Reynolds Creek area will be monitored through 1987. Recreational surveys will be continued to provide baseline data on visitors, their activities, and location. The low number of regulatory violations in 1985 and 1986 compared to 1984 suggested that regular patrols by BLM personnel in the BOPA were successful in influencing behavior of visitors.

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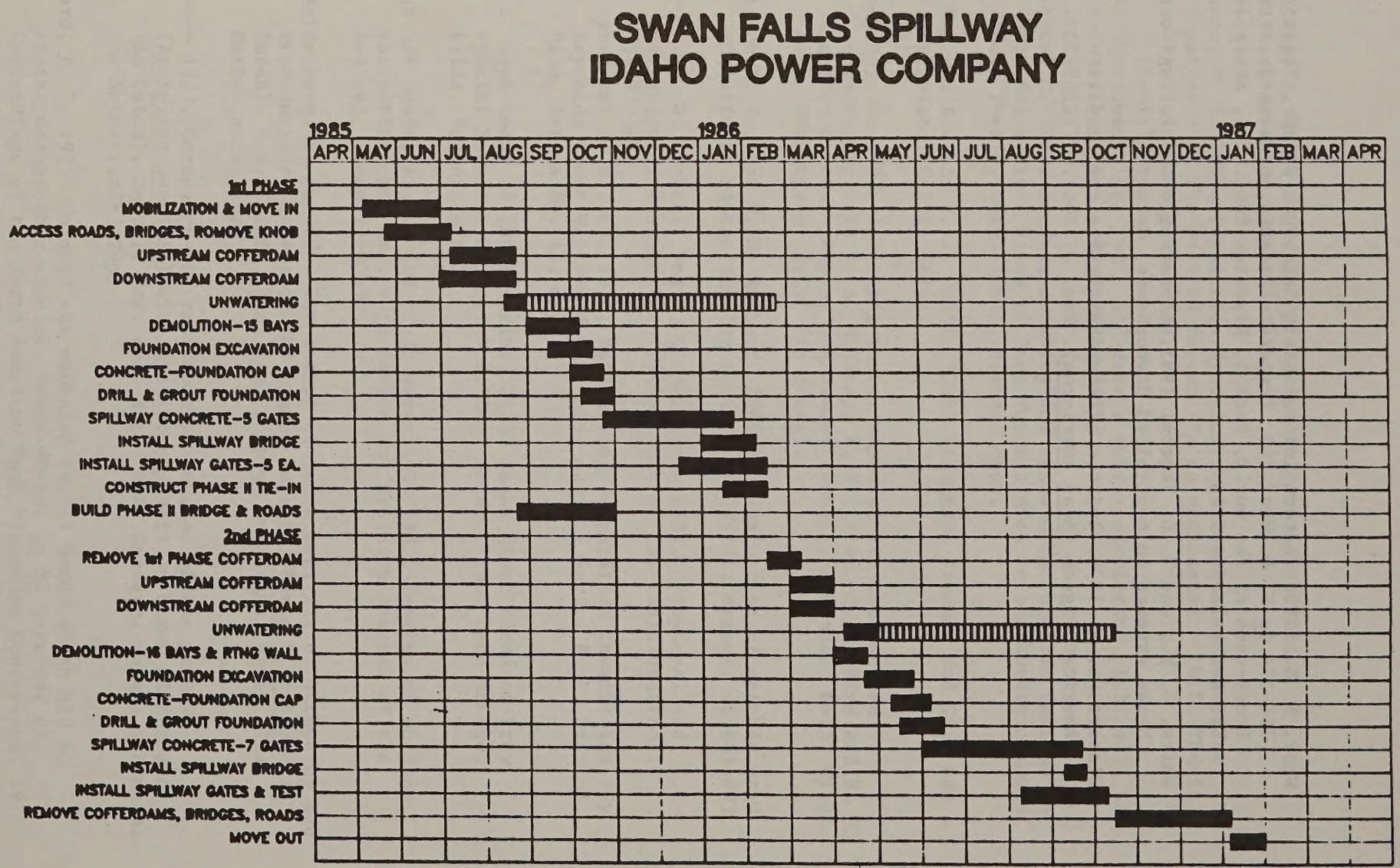
APPENDIX I. Construction schedule for the Swan Falls Dam spillway 1985-1987.



APPENDIX II. Definitions of behavioral categories used in continuous behavioral observations of prairie falcons.

Feeding: feeding young, feeding adult.

Resting/sleeping/perching: inactively perching, no head or body movements.

Preening: cleaning, oiling, positioning feathers.

Flying-in-canyon: flying within sight in or above the canyon.

Out-of-canyon: flying out of sight out of the canyon; this category was used when the bird left the canyon.

Copulation: male alights on the females back; contact of the cloacas.

Incubating: lie posture covering the eggs.

Brooding: sheltering the chicks.

Unattended: eggs or chicks are left unattended by adults.

Perched-out-of-view: falcon is known to be perched in the canyon but cannot be observed.

Inside aerie out-of-view: falcon(s) inside aerie, but not visible.

Nest visit: adult entering the scrape for less then 1 min.

Prey species: abbrevation common name, or in case prey cannot be identified to species level, category (mammal, bird, reptile, or other).

Prey delivery: delivery of prey item to the nest site territory.

Prey cached: prey is hidden in nesting territory, generally in a small cave or a clump off grass.

Prey retrieved: prey retrieved in nesting territory.

Inter- and intraspecific interactions

Vocalization: alarm call, lowest level of aggression.

Aggressive: stooping, chasing, following of intruder.

Non-aggressive: mutual display, soaring, no overt aggression.

Defensive: avoidance, flying directly away.

APPENDIX III. Stepwise discriminant analysis to evaluate differences in behaviors of male and female prairie falcons (expressed as percentages of total observation time/day) between early and late nesting pairs for pre-incubation, incubation, and brood-rearing stages, nesting season 1986 (Halverson Lake nesting territory excluded). N denotes number of observation days. Only P-values <0.10 included.

	Pre-incubation (N=41)						Incubation (N=68)						Brood-rearing (N=40)					
	Male			Female			Male			Female			Male			Female		
Variables	R^2	F	P	R^2	F	P	R^2	F	P	R^2	F	P	R^2	F	P	R^2	F	P
Perching	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Preening	–	–	–	–	–	–	0.01	3.82	0.05	–	–	–	–	–	–	–	–	–
In aerie	–	–	–	0.01	11.6	0.01	–	–	–	–	–	–	–	–	–	–	–	–
Incubating	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Brooding	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Canyon flight	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Out-of-view	–	–	–	–	–	–	–	–	–	–	–	–	0.01	4.13	0.04	–	–	–
Out-of-canyon	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Perched-out-of-view	–	–	–	–	–	–	–	–	–	0.01	3.87	0.04	–	–	–	–	–	–

ASCC male incubation=0.007
ASCC male brood-rearing=0.005
ASCC female pre-incubation=0.01
ASCC female incubation=0.005

APPENDIX IV. Stepwise discriminant analysis to evaluate differences in behaviors of male and female prairie falcons (expressed as counts/day) between early and late nesting pairs for pre-incubation, incubation, and brood-rearing stages, nesting season 1986 (Halverson Upper Lake nesting pair excluded). N denotes number of observation days. Only P-values <0.10 included.

	Pre-incubation (N=41)						Incubation (N=68)						Brood-rearing (N=40)					
	Male			Female			Male			Female			Male			Female		
Variables	R^2	F	P	R^2	F	P	R^2	F	P	R^2	F	P	R^2	F	P	R^2	F	P
Nest visit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Patrolling	-	-	-	0.01	4.41	0.03	-	-	-	-	-	-	-	-	-	-	-	-
Aggression	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copulation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Relocation	-	-	-	-	-	-	0.01	3.80	0.05	-	-	-	-	-	-	-	-	-
Feeding	0.01	13.1	0.01	-	-	-	0.01	5.15	0.02	0.01	0.01	0.07	0.01	4.38	0.03	-	-	-
Prey delivery	0.01	3.36	0.06	-	-	-	0.01	12.2	0.01	-	-	-	0.01	7.49	0.01	-	-	-

ASCC male pre-incubation=0.02
ASCC male incubation=0.02
ASCC male brood-rearing=0.02
ASCC female pre-incubation=0.01
ASCC female incubation=0.006
ASCC female brood-rearing=0.003

APPENDIX V. Analysis of variance to test for differences in behaviors of male and female prairie falcons (expressed as percentages of total observation time per half-day) as determined by observations made in and out of a blind in (A) mornings (N=15), and (B) afternoons (N=15) at the Priest Upper nesting territory, 1986 nesting season.

A. Morning

Variables	Male		Female	
	F	P	F	P
Perching	0.94	0.35	0.34	0.57
Preening	0.53	0.48	0.09	0.77
Incubating/ Brooding	0.01	0.91	0.53	0.48
Canyon flight	0.38	0.54	0.16	0.69
Out-of-view	2.30	0.15	0.59	0.45
Out-of-canyon	0.29	0.59	1.42	0.25

B. Afternoon

Variables	Male		Female	
	F	P	F	P
Perching	0.11	0.74	0.10	0.75
Preening	0.16	0.69	0.17	0.68
Incubating/ Brooding	0.07	0.79	0.02	0.89
Canyon flight	<0.01	0.96	0.09	0.76
Out-of-view	0.03	0.86	0.65	0.43
Out-of-canyon	0.41	0.53	0.14	0.71

APPENDIX VI. Analysis of variance to test for differences in behaviors of male and female prairie falcons (expressed as counts per half-day) as determined by observations made in and out of a blind in (A) mornings (N=15), and (B) afternoons (N=15) at the Priest Upper nesting territory, 1986 nesting season.

A. Morning

	Male		Female	
Variables	F	P	F	P
Nest visit	2.61	0.13	0.26	0.61
Patrolling	0.74	0.40	0.10	0.75
Aggression	0.97	0.34	0.07	0.79
Copulation	0.60	0.45	0.47	0.50
Relocation	0.03	0.86	2.88	0.11
Feeding	-	-	4.33	0.05
Prey delivery	0.02	0.89	-	-

B. Afternoon

	Male		Female	
Variables	F	P	F	P
Nest visit	1.48	0.24	1.32	0.27
Patrolling	0.01	0.92	0.83	0.37
Aggression	2.00	0.18	0.04	0.84
Copulation	0.05	0.82	0.04	0.85
Relocation	0.05	0.82	0.47	0.50
Feeding	-	-	0.35	0.56
Prey delivery	0.35	0.56	-	-

APPENDIX VII. Occupancy of prairie falcon nesting territories in the Swan Falls, Dedication Overlook and Tick Basin study locations, 1973-1986.

Nesting territory	Year[1]													
	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Swan Falls														
Balls Basin Powerline[2]	2	-	2	4	4	4	4	-	2	1	1	1	1	1
Falcon Flats Fingers	2	-	-	5	5	3	1	1	2	2	2	4	4	5
Ferry	2	-	-	4	2	1	-	1	2	-	1	4	5	1
Swan Dam Road Turn[2]	2	4	-	4	2	2	2	-	-	1	4	4	1	4
Swan Road N Side[2]	2	-	4	4	4	4	2	4	-	2	3	4	4	4
Swan Dam Three Poles	-	4	2	4	1	1	5	3	2	4	4	4	4	1
Falcon Flats Brown Rock	-	5	-	3	2	4	4	3	3	4	4	2	2	5
Dedication Overlook														
Beecham	2	4	-	-	2	1	2	-	1	1	1	1	1	-
Beecham Gate	-	-	4	3	-	4	2	4	2	2	2	1	1	-
Beecham Gate Dwnstream	-	-	2	3	-	1	1	1	1	1	1	1	1	-
Camera	4	-	4	3	5	3	4	4	4	4	2	4	4	4
Dedication Point	2	-	3	3	2	2	4	2	4	2	4	4	4	2
Dedication Site	2	4	4	2	3	2	2	4	3	4	5	1	1	5
PF I	2	2	4	4	4	2	1	1	2	5	4	4	4	1
PF II	2	-	4	4	4	2	1	5	2	2	1	4	4	5
Priest Lower	2	4	4	1	1	5	5	-	-	2	-	1	1	1
Priest Rapids I	2	2	2	3	2	4	2	1	2	-	-	5	4	5
Priest Rapids II	-	-	2	3	2	2	2	2	-	4	-	3	3	1
Priest Upper	2	4	4	4	4	4	2	2	4	4	2	4	4	4
Halverson Upper Lake	-	-	-	2	-	1	-	-	-	-	-	-	-	5
Tick Basin														
Tick City	-	-	-	-	-	-	-	2	5	5	2	2	4	1
Tick I	5	4	4	4	4	4	2	4	2	4	4	2	1	4
Tick II	3	4	4	4	5	4	2	4	4	3	2	3	4	4
Tick III	5	1	4	4	3	2	5	4	2	4	2	2	4	4
Tick IV	-	-	-	4	4	1	2	1	4	4	3	2	1	1
Red Trail	2	2	4	3	2	4	4	2	2	3	2	2	4	4
San Sebastian Basin	-	-	-	1	1	2	1	2	1	4	3	3	-	5

[1]Only in the years 1976, 1977, and 1978 were the 2 study locations completely surveyed and the data used to calculate occupancy rates.
[2]Nesting territories located along the Swan Falls access road.
[3]Unpublished data Bureau of Land Management, Boise, Idaho.
[4]Coding occupancy: 1=vacant; 2=occupied undetermined breeding; 3=breeding undetermined success; 4=breeding successful; 5=breeding unsuccessful.

TITLE: Feeding Ecology of the Common Barn-owl in the Snake River Birds of Prey Area.

INVESTIGATOR: Carl D. Marti, Department of Zoology, Weber State College, Ogden, Utah 84408.

OBJECTIVES:

1. Determine food habits and other food niche parameters of nesting common barn-owls (Tyto alba).

2. Determine food niche variation (a) among sites and (b) among years.

3. Determine the barn-owl's position in the raptor feeding guild.

INTRODUCTION

Field studies for this project began in 1978 and have continued through 1986. All data reported here were obtained in the Snake River Birds of Prey Area (BOPA) which is described in U.S. Dep. Inter. (1979). Analysis and subsequent statistical treatments were done at Weber State College, Ogden, Utah. Reports on previous years are also available (Marti 1979, 1981, 1982, 1983, 1984, 1985).

This report summarizes field activities and preliminary analysis for 1986 data. An index to trends in barn owl numbers in the BOPA is also proposed.

ANNUAL REPORT

Two visits were made to the BOPA to collect data in 1986: 25-27 April and 24-25 May. An additional collection of pellets made on 13 July by Jeff Marks is also included in the data presented here. Eleven samples of regurgitated pellets were collected from 5 sites (Table 1). A summary of the prey content of these pellets is in Table 2.

Dietary frequencies of only 2 major prey species showed noteworthy changes relative to preceeding year. Microtus frequency dropped 18% from its level in 1985 while the frequency of Mus increased 9% over 1985.

The most significant development revealed by this investigation in 1986 was an apparent large drop in numbers of nesting barn-owls. Evidence supporting the conclusion that barn-owl numbers were down in 1986 on the BOPA comes from the number of occupied traditional nest sites and quantities of pellets recovered in relation to previous years. This evidence is largely indirect because many nest sites were not entered to ascertain the number of adult owls occupying them or whether reproduction was attempted. However, several sites that have been occupied every year from 1978 through 1985 were vacant in 1986. Data from 1986 are compared to other years in Table 3. Data were gathered under the same protocol and with approximately the same degree of effort in each year. Thus, they may serve as an approximate index to the relative number of barn owls occupying the BOPA.

Table 1. Collection sites for common barn-owl food habits data in the BOPA, 1986.

Kitten's
Jensen Cliff
Castle Rock
Lower Lower Black Butte
Upper Lower Black Butte

Table 2. Total prey identified for the common barn-owl in the BOPA, 1986.

Prey Species	Number	Percent Number
MAMMALS		
Sorex vagrans	9	0.9
Mus musculus	142	14.3
Peromyscus spp.	123	12.3
Reithrodontomys megalotis	68	6.8
Neotoma lepida	2	0.2
Microtus montanus	389	39.1
Perognathus parvus	40	4.0
Dipodomys ordii	28	2.8
Thomomys townsendii (juvenile)	170	17.1
unidentified leporids (neonate)	1	0.1
BIRDS		
Sturnus vulgaris	3	0.3
unidentified icterid	3	0.3
unidentified medium bird	5	0.5
unidentified small bird	12	1.2
Unidentified scorpion	1	0.1
Totals	996	100.0

Table 3. Comparison of pellet collection data from nest sites of common barn-owls in the BOPA.

	Year of collection							
	1979	1980	1981	1982	1983	1984	1985	1986
Number of active sites	15	13	25	16	16	19	15	5
Number of pellet collections	33	18	38	22	28	33	26	11
Total number of prey	5426	3326	5359	5074	4142	7475	5559	996
Number of visits for collection	3	3	3	2	3	3	3	2

PLANS FOR 1987

Two or 3 trips to the BOPA are planned for the spring/summer of 1987. The primary goal for 1987 is to continue collecting food habits data for the analysis of long-term predation trends by barn-owls.

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I thank Michael Kochert, Karen Steenhof, John Doremus, Lenny Young, and all of the Snake River Birds of Prey Research staff for a variety of assistance in carrying out this study. Thanks also to Jeff Marks for making a collection of pellets. The Bureau of Land Management provided a vehicle for field use and living space in field camps. Weber State College provided a Faculty Research Grant covering travel to the study area from Ogden, Utah, and laboratory space and computer facilities for data analysis.

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U.S. Department of Interior. 1979. Snake River Birds of Prey Special Research Report. Bur. Land Manage., Boise Distr., Boise, Idaho. 141pp.

TITLE: Use of Nest Boxes, Reproduction, Food Habits, and Annual Weight Cycle of Western Screech-Owls in the Snake River Birds of Prey Area.

INVESTIGATORS: John Doremus, Wildlife Biologist, Bruneau Resource Area
Jeff Marks, Wildlife Biologist, Cascade Resource Area

OBJECTIVES: To determine patterns of nest box use, reproductive success, food habits, and annual cycle of body mass of western screech-owls.

METHODS

Nest boxes were available to western screech-owls (Otus kennicottii) at 15 sites in the Snake River Birds of Prey Area at the start of 1986 (Table 1). Excepting the Priest Upper site (which was never visited in 1986), occupied sites were visited at least once each month from January through June and in October and November. During each visit, we collected pellets and prey remains, banded all new owls encountered, and recorded body mass of all adult-sized owls. New boxes were installed at 10 additional sites during autumn 1986 and at 1 site in January 1987.

RESULTS AND DISCUSSION

Screech-owls occupied boxes at 9 sites, 2 of which were used only during the nonbreeding season. The 5 pairs that attempted breeding laid 22 eggs (mean clutch = 4.4 $\pm$ 1.34 [SD], range = 2-5), at least 18 of which hatched. At least 9 young fledged from 2 sites, 2 breeding attempts failed, and the outcome was unknown at 1 site. All young died in the box after the female was killed by a vehicle at Black Sands III, and both eggs failed to hatch for unknown reasons at Tom Draw (the nest may have been disturbed during egg-laying). Honey bees (Apis mellifera) invaded the box at Cellarhole at about the time that the young should have been ready to leave the box, and we did not determine whether any young fledged.

We banded 17 screech-owls during 1986 (11 nestlings and 6 adult-sized owls). The total number of owls banded from 1980 through 1986 is 83 (45 nestlings and 38 adults). A nestling (sex unknown) banded at Bruneau Boat Launch in May 1985 occupied a box at Bruneau Marsh (4.4 km from Bruneau Boat Launch) from November 1985 to February 1986 but was gone by early March. Both members of the pair that bred at Bruneau Marsh (egg-laying began in early April) were unbanded when first encountered at the site.

We obtained 52 weights from 18 adult-sized owls (6 males, 6 females, and 6 of unknown sex). Male weights ranged from 159-217 g, female weights from 202- 292 g, and sex-unknown weights from 185-252 g. As we have found in previous years, female weights peaked during egg-laying, whereas male weights were relatively constant (see Table 2).

Table 1. Site names and year-round occupancy status at nesting/roosting boxes available to western screech-owls in the Snake River Birds of Prey Area in 1986.

Site name	Site checked 1986	Status	Fate of nesting attempt
Black Butte-Lower Lower	Yes	Vacant	
Black Sands III	Yes	Breeding	Unsuccessful
Bruneau Boat Launch	Yes	Occupied	Unknown breeding
Bruneau Arm	Yes	Vacant	
Bruneau Marsh	Yes	Breeding	Successful
Cabin Draw	Yes	Occupied	Unknown breeding
Castle Creek Mouth N	Yes	Breeding	Successful
Cellarhole	Yes	Breeding	Unknown success
Dunes Entrance Pond	Yes	Vacant	
Flatiron Marsh	Yes	Vacant	
Harris	Yes	Occupied	Vacant in spring
Jack's Creek	Yes	Occupied	Vacant in spring
Priest Upper	No		
Rabbit Springs	Yes	Vacant	
Tom Draw	Yes	Breeding	Unsuccessful

Table 2. Body mass of 2 adult western-screech owls in the Snake River Birds of Prey Area in 1986. Seasonal weight changes fit the typical pattern found in previous years for this population of owls.

Band no.	Sex	Date	Body mass (g)
795-43995	F	20 January	254
		8 February	257
		5 March	256
		25 March	291
		10 May	237
		23 May	202
		29 November	252
795-43996	M	20 January	178
		8 February	161
		5 March	178
		25 March	180
		29 November	190

Single northern saw-whet owls (Aegolius acadicus) were captured at Bruneau Marsh and at Bruneau Boat Launch on 5 March. The Bruneau Marsh saw-whet was never encountered again. The saw-whet at Bruneau Boat Launch was incubating 1 egg on 5 March and a complete clutch of 6 eggs on 25 March. All 6 of the eggs hatched, and at least 5 young fledged during the first week of May. This is the first documented breeding record for saw-whet owls in the Snake River Birds of Prey Area. The resident male screech-owl at Bruneau Boat Launch occupied the box adjacent to the one used by the saw-whets ($\pm$25 m away) at least until the second week of April. We were not able to determine whether screech-owls attempted to nest at the Bruneau Boat Launch site.

A pair of American kestrels (Falco sparverius) raised 5 young in one of the boxes at the Harris site.

TITLE: Use of Nest Boxes by American Kestrels in Southwestern Idaho.

INVESTIGATORS: Karen Steenhof, Wildlife Research Biologist, B.L.M
Craig Groves, Director, Idaho Natural Heritage Program
Deana Ramirez, Data Transcriber, BLM

COOPERATORS: Idaho Department of Fish and Game, Nongame Program
Idaho Department of Transportation
The Nature Conservancy

OBJECTIVES:

1. Determine kestrel occupancy rates and nesting success at boxes erected in southwestern Idaho.
2. Ascertain food habits of American kestrels nesting in boxes placed in a variety of habitats.
3. Mark nestling and adult kestrels to accumulate baseline data for future studies on dispersal and population dynamics.

INTRODUCTION

In 1985, 20 nest boxes were erected on abandoned power poles in the Snake River Birds of Prey Area in an effort to learn more about the food habits and breeding biology of American kestrels (Falco sparverius) in southwestern Idaho (Steenhof et al. 1985). The limited use of those boxes prompted curiosity about factors that influence occupancy rates. The variables that might influence whether a box is used are: suitability of the nesting substrate itself, suitability of foraging habitat in the surrounding areas, availability of alternative nesting sites, and availability of kestrels to colonize boxes. Interest by the Idaho Fish and Game Department's Nongame program in a high-visibility program provided an opportunity to examine these factors.

METHODS

Thirty-six additional boxes were constructed following the design described by Steenhof et al. (1985). Eighteen of the boxes were placed on trees within agricultural habitat in the vicinity of Kuna, Idaho (hereafter referred to as the Kuna Route) on 23 March 1986. Most of the boxes were placed in groves of large trees near homes or farmlots. Boxes faced in all directions, and heights ranged from 2 to 4 m. The remaining 18 boxes were placed on signs along Interstate-84 between Simco Road and Caldwell (hereafter referred to as the I-84 Route) on 28 March. Boxes were placed on the backs of signs at heights ranging from 2 to 5 m. Some of the I-84 boxes were in agricultural habitat, and others were surrounded by a shrubsteppe environment.

Each box was checked at least 3 times during the nesting season. Checks were made in early May, late May, and late June. Boxes with viable nesting attempts were re-visited to ascertain success. Investigators checked boxes from a ladder or while standing on a vehicle. When checking boxes,

investigators inserted a hole stuffer into the nest box entrance to trap any adult birds in the box. Adults and young were weighed with a 300 g Pesola balance. Nests of European starlings (Sturnus vulgaris) were removed in an effort to keep all boxes suitable for kestrel nesting.

RESULTS

Two boxes (1 on the Kuna Route and 1 on the I-84 Route) were knocked down and were unavailable for nesting. Of the remaining 54 boxes, 8 were used by kestrels, 22 were used by starlings, and 3 were used by house sparrows (Passer domesticus). The I-84 route had the highest kestrel occupancy rate (4 of 17 boxes) and also the highest starling occupancy rate (12 of 17). All of the I-84 boxes occupied by kestrels were in agricultural or suburban habitat. The Kuna Route had the 2nd highest use rates with 3 of the 17 boxes occupied by kestrels, 8 by starlings, and 3 by sparrows. Only 1 kestrel pair nested along the power line within the Birds of Prey Area (hereafter referred to as the BOPA route).

All 4 of the pairs using boxes on the I-84 Route successfully raised young that fledged, but none of the 3 pairs using boxes on the Kuna Route hatched young. The single pair on the BOPA route hatched and raised young, but it is not known whether the young reached fledging age.

Clutch sizes in this study were either 4 (N=3) or 5 (N=4). Clutch sizes averaged 4.75 on the I-84 Route and 4.33 on the Kuna Route. One egg failed to hatch in each of 2 boxes on the I-84 route, but all young that hatched survived.

Six adult females and 21 nestlings were banded during the study. Two different adult females were found in the occupied box on the BOPA Route. One was found and banded on 5 May when the box contained no eggs. On 20 May an unbanded female was in the same box with 1 egg; the unbanded female was banded when found again 6 days later with 3 eggs. Adult females were captured and banded at 4 other boxes; 2 of these were recaptured in the same box.

Weights of adult females varied from 118 to 160 g. The heaviest female was a pre-laying bird that was eventually replaced by a different female. There was some indication that hatching success was related to weight of females during incubation. All 3 females that failed to hatch young weighed less than 140 g during incubation. In contrast, 2 of the females that hatched and raised young weighed 140 g or more during laying/incubation. A female from an I-84 box that successfully produced 5 young showed a weight gain from 140 g on the 5th day of incubation to 144 g on the final day of incubation. However, a female from a Kuna box that failed to hatch young decreased in weight from 145 g to 136 g during approximately the same period. Additional data are needed to verify these trends because sample sizes are small.

All pellets and prey remains collected from boxes occupied by kestrels were shipped to Carl Marti for analysis. Results will be available in 1987.

ACKNOWLEDGMENTS

We thank A. Ogden, W. Melquist, A. Taye, R. B. Erickson, and C. Holden for assisting in box construction. R. Tiedemann was instrumental in obtaining permission to place boxes on the interstate signs, and he also assisted in erecting and checking boxes. We are especially indebted to the landowners in the Kuna area who graciously allowed us to set up and check boxes on their property.

LITERATURE CITED

Steenhof, K., D. Ramirez, and J. Doremus. 1985. Use of nest boxes by American kestrels in the Snake River Birds of Prey Area. Pages 138-144 in K. Steenhof and M.N. Kochert, eds. Snake River Birds of Prey Research Proj. Annu. Rep., Bur. Land Manage. Boise, ID.

TITLE: Use of Artificial Nest Platforms by Raptors and Ravens.

INVESTIGATORS: John H. Doremus, Wildlife Biologist, Bruneau Resource Area
Randy Trujillo, Wildlife Biologist, Bruneau Resource Area
Raul Morales, Wildlife Biologist, Owyhee Resource Area

OBJECTIVE:

To monitor occupancy of artificial nest platforms in the Bruneau, Jarbidge, and Owyhee Resource Areas.

METHODS

During 1986, 27 artificial nest platforms (Table 1) were in place in the Bruneau, Jarbidge, and Owyhee Resource Areas of the Boise District, Bureau of Land Management. Each platform was visited at least once during or shortly after the ferruginous hawk (Buteo regalis) breeding season (March to July). Platforms, where occupancy or breeding was not confirmed by ground observation, were climbed into and inspected for new nest material, feathers, eggs, or eggshell fragments.

RESULTS

Thirteen platforms (Table 1) were occupied during the 1986 breeding season. Eleven were occupied by 1 or more ferruginous hawks, 1 by a pair of red-tailed hawks (Buteo jamaicensis), and 1 by a pair of common ravens (Corvus corax).

A total of 10 ferruginous hawk young fledged from 3 platforms. Three other platforms contained a total of 10 young ferruginous hawks between 14 to 21 days of age at the last visit. One pair of ferruginous hawks bred unsuccessfully, probably failing during incubation. Four platforms were occupied by 1 or more ferruginous hawks. There was no sign of a breeding attempt at these sites when they were inspected. The red-tailed hawks were seen incubating, but it is not known if they successfully fledged young. The raven pair had 1 young between 20 to 25 days of age at the last visit to their platform.

Table 1. Utilization of artificial platforms by raptors and ravens, 1986.

Platform Name	Species	Fate
Jarbridge R.A.		
Hot Springs I	--	Vacant
Hot Springs II	--	Vacant
Hot Springs III	--	Vacant
Owyhee R.A.		
Nahas Corral*	--	Vacant
Nahas Corral RTH*	RTH	Breeding Unknown Success
Bruneau R.A.		
Artesian Well	--	Vacant
Baker	--	Vacant
Bryan's Run	FH	Breeding Successful
Bullseye	--	Vacant
Cabin*	FH	Occupied/Nonbreeding
Cabin Platform*	FH	Breeding Unsuccessful
Castle Creek	--	Vacant
Cheatgrass	FH	Occupied/Nonbreeding
Halfway Gulch	--	Vacant
Hinton Reservoir	--	Vacant
Hot Springs Creek Road	FH	Breeding Unknown Success
Indian Creek Reservoir	FH	Breeding Successful
Leone	--	Vacant
Missle Road	--	Vacant
Old Beacon Inn	--	Vacant
Old Hiway 30	FH	Occupied/Nonbreeding
Powerline*	FH	Breeding Successful
Shoofly	--	Vacant
Simco Railroad	FH	Occupied/Nonbreeding
Slater Flat	FH	Breeding Unknown Success
Soles Rest Creek Area	FH	Breeding Unknown Success
Vinson's Wash	RA	Breeding Unknown Success

* Platforms in the Snake River Birds of Prey Area.

TITLE: Occupancy of Disturbed and Undisturbed Long-eared Owl and Northern Harrier Nest Sites in the Snake River Birds of Prey Area.

INVESTIGATORS: John H. Doremus, Wildlife Biologist, Bruneau Resource Area
Nina Walker, Volunteer Technician
Lydia Kading, Volunteer Technician

OBJECTIVE:

To compare the occupancy of long-eared owls (Asio otus) and northern harriers (Circus cyaneus) in areas of high and low human disturbance.

METHODS

Long-eared Owls

Five long-eared owl sites in areas of high human disturbance and 6 long-eared owl sites in areas of low human disturbance were visited at least twice during the incubation and brood rearing period (April through June). During each visit the riparian vegetation was carefully searched for owls and nests. Nests found within each site were observed for signs of long-eared owl occupancy.

Northern Harriers

Six sites in areas of moderate to high human disturbance were visited at least 3 times during the courtship and breeding periods (March to July). The 7 control sites were visited 5 times during the courtship and breeding periods. The sites were observed from a vehicle parked 200 to 600 m from the site, or from promontories 300 to 750 m from the sites. The length of the observations varied from 10 minutes to 5 hours.

RESULTS

Long-eared Owls

Two of the 5 high disturbance sites were occupied by long-eared owls (Table 1). The Tom Draw nest was predated during incubation by a mammalian predator, probably a raccoon. The Cabin GE Draw nest probably failed in late incubation or early brood rearing.

Two of the 6 sites in the area of low human disturbance were occupied during the incubation and brood rearing period (Table 1). The Rye Patch pair fledged at least 3 young. The cause and time of the failure at the Rye Patch Tree Downstream site is not known.

Northern Harriers

Three of the 6 high disturbance sites were occupied by northern harriers (Table 1). The "Sugar" site had young of undetermined age on 25 June. Tom Draw was occupied by aggressive adults on 16 June, but the nest was not searched for or found. Courting adults were seen at Crane Falls Lake in April but no birds were seen at this site in June.

Table 1. Occupancy and nesting success of long-eared owls and northern harriers at high and low disturbance sites, 1986.

High Disturbance		Low Disturbance	
Long-eared Owls			
Tom Draw	Breeding Unsuccessful	Rye Patch	Breeding Successful
Crane Falls	Vacant	Rye Patch Tree	Vacant
Crane Falls Sturgeon	Vacant	Rye Patch Tree Downstream	Breeding Unsuccessful
Cabin Draw	Vacant	Fossil Creek I	Vacant
Cabin GE Draw	Breeding Unsuccessful	Fossil Creek II	Vacant
		Fossil Creek III	Vacant
Northern Harriers			
Balls Basin Duck Blind	Vacant	Strike Dam	Vacant
Balls Basin	Vacant	Strike Dam Marsh	Insufficient Data
Tom Draw	Occupied Unknown Breeding	Strike Dam Marsh Yellow	Breeding Unknown Success
Cabin	Vacant	Strike Dam Marsh Brown/Gray	Breeding Unknown Success
Crane Falls Lake	Occupied Unknown Breeding	Strike Dam Marsh Green	Occupied Unknown Breeding
Sugar	Breeding Unknown Success	Strike Dam Marsh West	Occupied Unknown Breeding
		Strike Dam Marsh North	Vacant

Four of the 7 low disturbance sites were occupied by northern harriers (Table 1). Strike Dam Marsh Brown/Grey and Strike Dam Marsh Yellow hatched young, but it is not known if any young fledged at these sites. Strike Dam Marsh Green and Strike Dam Marsh West sites were occupied but breeding was not determined. After 5 visits to Strike Dam Marsh site, northern harrier activity was such that fate at this site could not be determined.

TITLE: Abundance of Black-tailed Jack Rabbits and Kangaroo Rats in the Snake River Birds of Prey Area.

INVESTIGATORS: John H. Doremus, Wildlife Biologist, Bruneau Resource Area
Lydia Kading, Volunteer Technician
Karen Steenhof, Associate Research Leader

OBJECTIVE:

To monitor changes in the black-tailed jack rabbit (Lepus californicus) populations in the Snake River Birds of Prey Area.

METHODS

Black-tailed jack rabbits were surveyed along 10 spotlight transects (Smith and Nydegger 1985) which run through major cover types within the study area. Each transect was sampled 3 times from mid-May to mid-June for a total of approximately 547 km. Data were analyzed using the computer program "TRANSECT" (Burnham et al. 1980). The locations of all kangaroo rats (Dipodomys ordii, D. microps) sighted during the jack rabbit survey were recorded.

RESULTS

The overall annual density index increased by 0.01 jack rabbits/ha from 1985 to 1986 (Table 1). The density of jack rabbits has continued to decline in the big sagebrush types (Table 2). Only 29 jack rabbits were observed on the 10 transects.

The number of kangaroo rats seen per unit effort (Table 3) varied from 0.15 to 2.76 animals/km depending on cover type. There was a small increase in these values since 1985.

LITERATURE CITED

Burnham, K. P., D. R. Anderson, and J. L. Laake. 1980. Estimation of density from line transect sampling of biological populations. Wildl. Monogr. 72. 202pp.

Smith, G. W., and N. C. Nydegger. 1985. A spotlight, line-transect method for surveying jack rabbits. J. Wildl. Manage. 49:699-702.

Table 1. Annual density estimates of black-tailed jack rabbits from spotlight transects in the Birds of Prey Area, 1977-1986.

Year	Number of Rabbits Observed	Density Index[a] (N/ha)	95% Confidence Interval	Coefficient of Variation
1977	218	0.16	0.14-0.18	6.86
1978	103	0.17	0.14-0.21	10.09
1979	701	0.49	0.46-0.53	3.84
1980	807	0.48[b]	0.43-0.53	4.98
1981	870	0.52	0.49-0.56	3.44
1982	282	0.14	0.13-0.16	6.05
1983	194	0.12	0.11-0.14	7.36
1984	59	0.05	0.04-0.06	13.31
1985	55	0.02	0.02-0.03	13.50
1986	29	0.03	0.02-0.04	19.06

[a] Calculated using the Exponential Power Series estimator in program TRANSECT (Burnham et al. 1980).

[b] Calculated using the Negative Exponential.

Table 2. Annual density estimates of black-tailed jack rabbits from spotlight transects in big sagebrush within the Birds of Prey Area, 1977-1986.

Year	Number of Rabbits Observed	Density Index[a] (N/ha)	95% Confidence Interval	Coefficient of Variation
1977	60	0.23	0.18-0.29	13.01
1978	54	0.67	0.48-0.85	14.45
1979	412	0.79	0.71-0.86	5.03
1980	455	0.75	0.68-0.82	4.76
1981	466	0.95	0.86-1.04	4.75
1982	163	0.29	0.25-0.34	7.96
1983	237	0.33	0.28-0.37	6.63
1984	36	0.05	0.06-0.19	26.70
1985	25	0.05	0.03-0.06	20.03
1986	14	0.03	0.01-0.04	27.01

[a] Calculated using the Exponential Power Series estimator in program TRANSECT (Burnham et al. 1980).

Table 3. Number of kangaroo rats seen per unit of effort (N/km) on the spotlighting transects within selected cover types, Snake River Birds of Prey Area, 1985 and 1986.

Cover Type	1985 Number/km	1986 Number/km
Big sagebrush	0.50	0.38
Big sagebrush/winterfat	0.50	2.26
Big sagebrush/shadscale	0.38	2.76
Winterfat	0.36	0.56
Shadscale	0.04	0.27
Shadscale/winterfat	0.11	0.36
Greasewood	0.00	0.42
Grass	0.48	0.21
All cover types pooled	0.39	0.41

TITLE: Short-Term Responses of Small Mammals and Vegetation to Wildfire in Shadscale Communities of Southwestern Idaho.

INVESTIGATORS: Craig R. Groves, Idaho Natural Heritage Program
Karen Steenhof, Associate Research Leader

OBJECTIVES:

To assess small mammal populations and vegetation composition in burned, partially burned, burned/rehabilitated, and unburned (control) areas 1 year after a wildfire in the BOPA.

ANNUAL SUMMARY

Wildfires have burned 50% of the shrub-steppe vegetation in the Snake River Birds of Prey Area during the last 10 years. Because of the importance of small mammals as prey for raptors, a study was conducted to assess small mammal populations and vegetation in burned, partially burned, burned/rehabilitated, and unburned (control) areas. Vegetation on unburned sites consisted primarily of shadscale (Atriplex confertifolia) and winterfat (Ceratoides lanata) associations, whereas cheatgrass (Bromus tectorum) dominated the burned sites. The deer mouse (Peromyscus maniculatus) was the most abundant species on all study sites. More deer mice were captured on partially burned and unburned sites than on burned and burned/rehabilitated sites. Townsend's ground squirrel (Spermophilus townsendii) numbers, as measured by hole counts, were greater on unburned sites than burned ones. Results of this study suggest that wildfires in shadscale habitat have the short-term effect of reducing small mammal abundance.

INTRODUCTION

Numerous studies have assessed the effects of fire on small mammal populations (Ream 1981). Although the majority of these studies were conducted in forested habitat, several recent investigations have focused on the impacts of fire on small mammals in shrub-steppe vegetation (Halford 1981, Hedlund and Rickard 1981, Gano and Rickard 1982, McGee 1982, Keller et al. 1983). During the last 10 years, approximately 50% of the shrub-steppe vegetation in the Snake River Birds of Prey Area (BOPA) in southwestern Idaho has burned (M. Pellant, unpubl. data). The BOPA supports one of the densest and most diverse assemblages of raptor populations in the world (U.S. Dep. Inter. 1979). Because all of the raptor species in the BOPA prey upon small mammals to some extent, fire could potentially affect raptor populations by reducing the rodent prey base through direct mortality and habitat alteration.

In July 1985, a wildfire burned approximately 2400 ha of shadscale (Atriplex confertifolia) habitat within the BOPA. During autumn 1985 and spring 1986, parts of this burn area were drill-seeded in a range rehabilitation effort (M. Pellant, pers. commun.). During summer 1986, we conducted a study to assess small mammal populations and vegetation in

burned, partially burned, burned/rehabilitated, and unburned (control) areas. This report presents our findings on small mammal species composition and densities as well as species composition and percent cover of vegetation in the 4 study areas.

METHODS

This study was conducted within the 242,884-ha Snake River BOPA in southwestern Idaho. Prior to recent, extensive range fires, vegetation within the BOPA was shrub steppe dominated by big sagebrush (Artemisia tridentata), shadscale, and winterfat (Ceratoides lanata) associations (U.S. Dep. Inter. 1979). The Snake River Canyon is the principal physiographic feature of the BOPA with elevation ranging from 770 m in the canyon bottom to 1000 m at the rim. Topography above the canyon is generally flat or slightly rolling with a few isolated buttes. Climate in the BOPA is characterized by hot summers and mild winters; average annual precipitation is 20 cm, most of which occurs in winter.

Small mammals and vegetation were sampled on and adjacent to the 2428-ha Black Butte burn, which is located on the north rim of the Snake River Canyon (Fig. 1). Vegetation in the burned area was dominated by shadscale and shadscale/winterfat associations prior to the burn (U.S. Dep. Inter. 1979).

During May and June 1986, we established transects for sampling small mammals and vegetation in each of 4 areas (Fig. 1); burned (B), partially burned (P), burned/rehabilitated (R), and control (C). The partially burned site was located on the southwestern corner of the burn where the fire burned incompletely and left patches of shrub cover. The burned/rehabilitated sites were those areas of the burn that had been drill-seeded in November 1985 (1860 ha) and March 1986 (240 ha) with a mixture of crested wheatgrass (Agropyron cristatum "Fairway" and Agropyron cristatum "Siberian"), yellow sweetclover (Melilotus officinalis), and fourwing saltbush (Atriplex canescens) (M. Pellant, pers. commun.). The control area was located adjacent to the burn on the west side and consisted primarily of shadscale associations.

Four 250-m transects were randomly located within each of the 4 study areas. Each consisted of 26 trap stations with a 10-m interval between stations. Eight of the 16 transects (B1,B2;P1,P2;R1,R2;C1,C2) were sampled in May with 2 Museum Special traps and 1 McGill rat trap at each station; the other 8 transects were sampled in June with only 2 Museum Special traps per station. Traps were baited with a mixture of peanut butter and whole oats. Following a 2-day prebait period, each transect was trapped for 3 consecutive days. For each animal captured, information on species, trap station, sex, weight, and reproductive condition was recorded. Males were considered to be in breeding condition if scrotal testes were observed; lacatation tissue, noticeable pregnancy, and perforate vaginas were indications of breeding condition for females.

Holes of Townsend's ground squirrels (Spermophilus townsendii) and badgers (Taxidea taxus) were censused in the 4 study areas on hole-count transects. Each of the 16 250-m trapping transects was extended 150

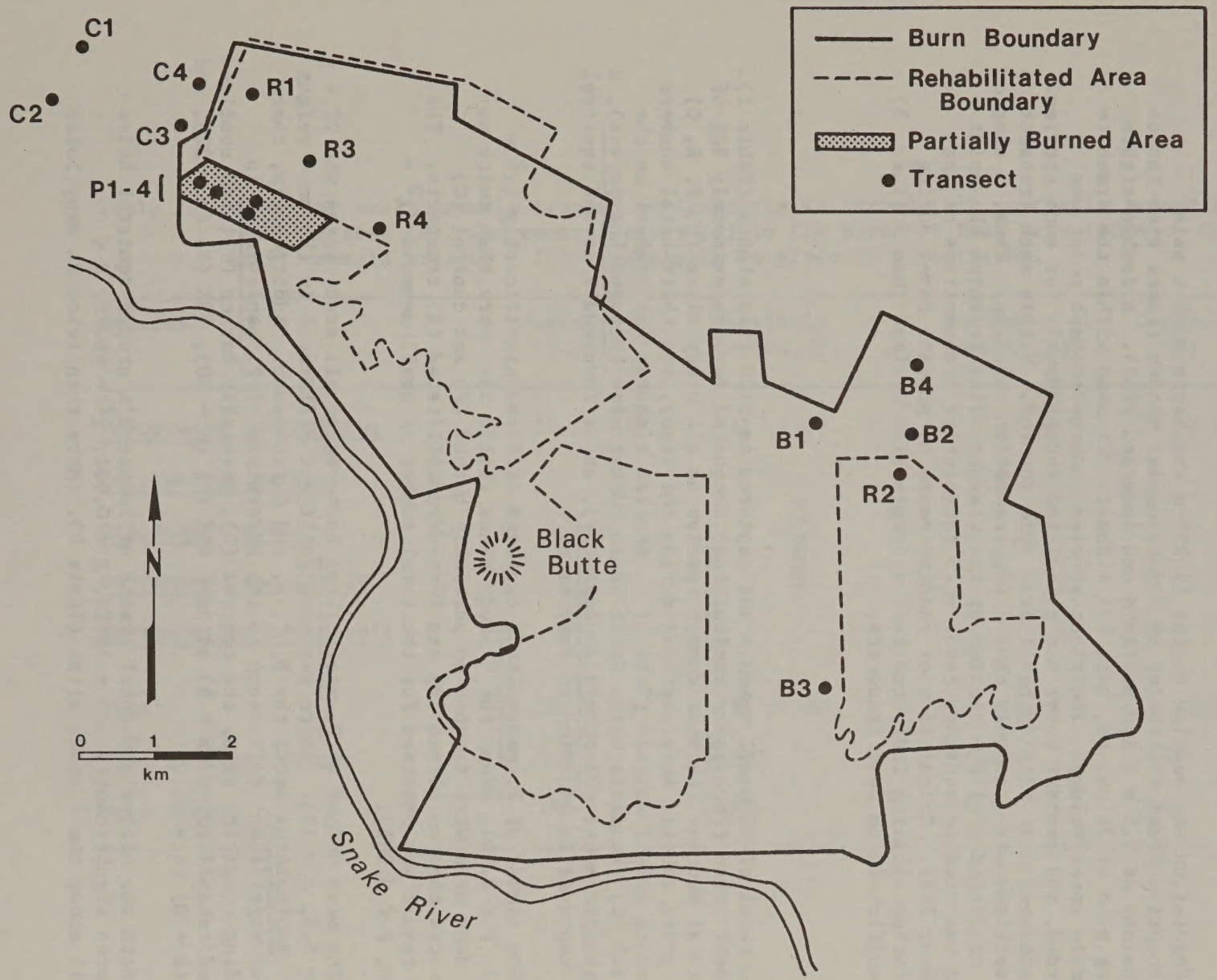

Fig. 1. Location of small mammal and vegetation sampling transects on and adjacent to the Black Butte burn. B = burned transects; C = control (unburned) transects; P = partially burned transects; R = burned/rehabilitated transects.

additional meters. An observer counted all ground squirrel and badger holes in belt transects that were 400 m long and 5 m wide with transect line serving as the center of the belt. Holes were classified as active if diggings indicated they were used by ground squirrels or badgers during 1986, whereas holes were recorded as inactive if they had last been used prior to 1986. Previous work in the BOPA has demonstrated a close correlation between the number of active holes and ground squirrel density ($r = 0.94$, $P = 0.002$) (Nydegger and Smith 1986).

Vegetation was sampled on the 16 250-m transects with a point interception frame consisting of 2 rectangular wooden frames with inside dimensions of 0.5 m x 1.0 m (Floyd and Anderson 1982). A double-sighted string grid of 36 points, each 0.1 m apart, was used within the frame to estimate cover values. The plant species underneath each point was recorded, and percent cover was calculated independently for each species. For grasses, only hits on basal area were counted. Within each transect, 5 5-m sections were randomly chosen for vegetation sampling. Thus, a sample unit consisted of 1 5-m section of the transect line in which the point frame was used to estimate cover on 5 consecutive 1-m sections of the transect line. Calculation of running means of percent cover during vegetation sampling indicated that a sample size of less than 5 (i.e., 3) was sufficient on most transects.

RESULTS

A total of 82 small mammals was captured in 3120 trap nights (Table 1). The deer mouse (*Peromyscus maniculatus*) accounted for approximately 90% of the total and was the most common species on all study sites (B, P, R, C). Four other species were captured during the study, but their total numbers summed to only 7 animals (Table 1). Species richness was highest on the control (C) transects where Great Basin pocket mice (*Perognathus parvus*), a grasshopper mouse (*Onychomys leucogaster*), and a Townsend's ground squirrel were captured in addition to deer mice.

The number of *P. maniculatus* captured differed significantly ($\chi^2 = 19.23$, $P < 0.001$) among the 4 study sites (Table 1). More than twice as many deer mice were trapped on partially burned (P) and control (C) transects than on burned (B) and burned/rehabilitated (R) transects. The same result was observed for the total number of small mammals ($\chi^2 = 17.70$, $P < 0.001$).

The mean weight of *P. maniculatus* captured on all study sites was 22.4 g (SD = 5.8, n = 59). There was no significant difference in the mean weight of *P. maniculatus* among the B, P, R, and C transects. Additionally, there was no significant difference in the percentage of *P. maniculatus* in breeding condition among the control (C), partially burned (P), and combined burned/rehabilitated (B + R) sites: 65% (C) (n = 20), 78% (P) (n = 22), and 56% (B + R) (n = 16).

Both the active and total number of Townsend's ground squirrel holes differed significantly ($\chi^2 = 19.23$, $P < 0.001$; $\chi^2 = 46.78$, $P < 0.001$) among the 4 study sites (Table 2). More than twice as many holes

Table 1. Number of small mammals trapped on transects in burned (B), partially burned (P), burned/ rehabilitated (R), and control sites (C) in the Birds of Prey Area (BOPA). Number of small mammals trapped / 100 trap nights is given in parentheses.

Species	Burned (B)	Partially Burned (P)	Burned/ Rehab. (R)	Control (C)	Total
Peromyscus maniculatus	10 (1.3)	31 (4.0)	9 (1.2)	25 (3.2)	75
Perognathus parvus			2	2	4
Dipodomys ordii	1				1
Onychomys leucogaster				1	1
Spermophilus townsendii				1	1
Total	11 (1.4)	31 (4.0)	11 (1.4)	29 (3.7)	82
Trap station nights	312	312	312	312	1248
Trap nights	780	780	780	780	3120

Table 2. Number of ground squirrel holes and badger diggings counted on transects in burned (B), partially burned (P), burned/rehabilitated (R), and control (C) sites in the Birds of Prey Area (BOPA).

Species	Burned (B)	Partially Burned (P)	Burned/ Rehab. (R)	Control (C)	Total
Spermophilus townsendii					
Active	9	19	7	29	64
Inactive	12	12	7	36	67
Total	21	31	14	65	131
Taxidea taxus					
Active	4	2	1	7	14
Inactive	13	8	10	31	62
Total	17	10	11	38	76

were counted on control transects compared to burned, partially burned, and rehabilitated transects. The total number of badger diggings was also significantly different ($\chi^2 = 26.83$, $P < .001$) among the 4 study sites (Table 2). Again, the greatest number of diggings was observed on control transects.

Vegetation in control (C) sites was dominated by a 14% cover of shadscale and a 7% cover of winterfat (Table 3). Important grasses were bottlebrush squirreltail (Sitanion hystrix) and cheatgrass (Bromus tectorum). In contrast, burned (B) and rehabilitation (R) sites had little or no shadscale and winterfat cover, but considerably more cover of cheatgrass (26 and 14%, respectively) and no Sitanion. Burned, partially burned, and control sites were characterized by 22% bare ground, whereas estimates of bare ground in the rehabilitation transects averaged 54% (Table 3). Cover values for litter ranged from 16% in the rehabilitation transects to 34% in burn transects. The control site contained the greatest number of plant species (10); the B and P sites contained the greatest number of exotic species (5). Burned and rehabilitated sites were devoid of any moss or lichen cover.

DISCUSSION

Previous studies on the effects of fire on small mammals have shown that the response of rodent populations to fire depends on the species involved, the type of vegetation, the type and intensity of the burn, and the timing of the study in relationship to time of the burn. The present study was conducted 1 year after an intense wildfire burned 2400 ha of shrub-steppe vegetation in the Snake River BOPA. Prior to the fire, vegetation in the burned areas was dominated by a 10% cover of shadscale and a 3% cover of cheatgrass (U.S. Dep. Inter., unpub. data). Our post-fire vegetation sampling showed that shadscale cover had decreased to less than 1% in burned and burned/rehabilitated sites and that cheatgrass had increased to approximately 26% in burned and 14% in burned/rehabilitated sites.

Previous censuses of small mammals in shadscale habitat of the BOPA showed the same species composition as this study (U.S. Dep. Inter. 1979). The number of small mammals captured was low for all species, except deer mice, in both burned and control areas. Previous studies in similar habitats with a similar sampling design have captured considerably greater numbers of these species (Larrison and Johnson 1973, U.S. Dep. Inter. 1979, Honeycutt et al. 1981, Putera and Steenhof, unpubl. data).

The number of deer mice captured in burned and control areas was also low when compared with other studies. An earlier BOPA study (U.S. Dep. Inter. 1979) reported relative densities (number of animals trapped/100 trap nights) of deer mice in shadscale ranging from 4.2 to 23 for the years 1975 - 1978. In "depleted" (heavily grazed) and "healthy" stands of shadscale in south-central Idaho, Larrison and Johnson (1973) reported relative densities of deer mice to be 14 and 7.8, respectively. Relative density of deer mice in this study (Table 1) was 3.2 (animals/100 trap nights) in grazed shadscale habitat (C transects) and approximately 1.2 in cheatgrass stands (B and R transects). In contrast, Putera and Steenhof

Table 3. Mean percent cover values for vegetation sampled on transects in burned (B), partially burned (P), burned/rehabilitated (R), and control (C) sites in the Birds of Prey Area (BOPA). Sample sizes (n) are given in parentheses.

Species	Burned (B) (n=12)	Partially Burned (P) (n=16)	Burned/ Rehab. (R) (n=12)	Control (C) (n=18)
Shrubs				
Atriplex confertifolia	x[1]	6	--	4
Ceratoides lanata	x	--	--	7
Artemisia spinescens	--	--	--	x
Dead Shrub	4	9	--	5
Grasses				
Sitanion hystrix	--	2	--	5
Poa sandbergii	3	--	--	--
Bromus tectorum[2]	26	9	14	5
Vulpia sp.	--	--	x	x
Forbs				
Sisymbrium loeselii[2]	3	3	x	2
Descurainia sophia[2]	5	3	6	x
Chenopodium leptophyllum	--	x	x	
Salsola kali[2]	x	x	--	--
Halogeton glomeratus	--	x	--	--
Plagiobothrys sp.	--	--	x	--
Amsinckia retrorsa	--	--	x	--
Bare Ground	22	22	54	22
Litter	34	26	16	20
Moss	--	2	--	7
Lichen	--	--	--	2
Total number of species	7	9	7	10

[1] x = species present but mean percent cover < 1.0.

[2] Species introduced to North America.

(U.S. Dep. Inter., unpubl. data) report 6.0 deer mice/100 trap nights in cheatgrass stands of southwestern Idaho in which fires had occurred 1 to 4 years prior to rodent sampling.

Both the number of deer mice and the total number of small mammals captured were significantly lower in burned sites (B) than in partially burned (P) and control (C) sites. This finding is in agreement with other studies in similar habitat. Rogers and Hedlund (1980) found deer mice in lower numbers in a cheatgrass community compared to needle-and-thread grass (Stipa comata) and sagebrush/juniper (Artemisia tridentata/Juniperus occidentalis) communities. Gano and Rickard (1982) reported 3 times as many small mammals in shrub-dominated unburned areas as cheatgrass-dominated burned areas. Larrison and Johnson (1973) commented that cheatgrass stands in south-central Idaho supported only a few pocket mice and deer mice.

Assuming that hole counts are a reliable index of population density, counts of Townsend's ground squirrel and badger holes revealed that these 2 species also had significantly lower numbers in burned (B, R, and P) sites than control sites (Table 2). A previous live-trapping study of Townsend's ground squirrels in the BOPA (Smith and Johnson 1985) concluded that densities did not differ significantly among several different vegetation types including cheatgrass. Smith and Johnson (1985) did note, however, that densities of ground squirrels in shadscale were too low to effectively study them there. Counts of Townsend's ground squirrel hole numbers in the BOPA, conducted at the same time as our study, have indicated a decrease in squirrel holes in all habitats between 1982 and 1986 (E. Yensen, pers commun.). These decreases were even greater in burned areas than in unburned ones. Furthermore, ground squirrel hole counts in Yensen's study showed a striking decrease with increased cheatgrass cover.

Counts of inactive holes may be a reflection of pre-fire squirrel densities. Control sites had significantly greater numbers of inactive holes than burned and rehabilitated sites. Therefore, we cannot conclude that fire is the primary factor responsible for lower hole counts in burned areas. However, if soil movement following fire destroys inactive holes, then data from this study and Yensen's study do suggest that fire is a major factor in reducing ground squirrel numbers in burned areas.

Deer mice appear to be the only species which has successfully colonized the cheatgrass-dominated areas in our study 1 year after a burn. The ecological tolerance of this species and its ability to successfully occupy disturbed sites have been documented in a number of studies (e. g., Kirkland 1976, McGee 1982, Groves and Keller 1983). It is particularly suited to exploit burned areas because of its ability to shift diets (Halford 1981, McGee 1982) following a fire.

Results of this study suggest that wildfire in shadscale habitat has the short-term effect of reducing small mammal abundance. In burned areas dominated by cheatgrass, 2 factors have been suggested as the cause of reduced small mammal populations. First, the loss of shrub cover may result in increased predation (Gano and Rickard 1982, Nydegger and Smith 1986) of small mammals, particularly in the BOPA where dense raptor populations exist. Second, thick stands of cheatgrass may impede small mammal movements which in turn may affect breeding success and population size (Gano and

Rickard 1982). Both of these factors could be responsible for the observed decreases in deer mice and Townsend's ground squirrel numbers, although other factors such as a change in available food resources could also be important.

Why small mammal populations were low in all study sites, especially in burned areas, is a difficult question to address in a short-term study. The fact that the entire study area has been grazed for many years prior to the fire confounds the question even further. Numerous studies have indicated that grazing is detrimental to small mammal populations (e. g., Bock et al., 1984), although there are studies to the contrary.

Results of this preliminary work and the ground squirrel surveys conducted simultaneously by E. Yensen (pers. commun.) point to the need for an experimentally manipulated and replicated study which can fully examine the responses of small mammals in the BOPA to several variables (weather, fire, grazing, range rehabilitation, etc.). This study should include the other major vegetation types (Artemisia and Ceratoides associations) in the BOPA, which have also extensively burned in recent years. It is only through such a study that substantive conclusions will be reached regarding the potential impacts of prey reduction by wildfire on raptor populations in the Birds of Prey Area.

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TITLE: Comparison of 1982 and 1986 Townsend's Ground Squirrel Burrow Entrance Transects in the Snake River Birds of Prey Area, Southwestern Idaho.

INVESTIGATORS: Kathrine Peterson
Eric Yensen

COOPERATOR: College of Idaho

OBJECTIVES:

1. Assess the status of Townsend's ground squirrels in the Snake River Birds of Prey Area (BOPA) during the 1986 raptor nesting season.

2. Evaluate methods used to estimate Townsend's ground squirrel density.

INTRODUCTION

Townsend's ground squirrels (Spermophilus townsendii or TGS) are a primary food source for nesting raptors in the Snake River Birds of Prey Area (BOPA). The breeding success of prairie falcons (Falco mexicanus) is closely tied to TGS abundance (U.S. Dep. Inter. 1979). TGS are also important prey of coyotes (Canis latrans), badgers (Taxidea taxus), western rattlesnakes (Crotalus viridis), and common ravens (Corvus corax) (Smith and Johnson 1985).

Townsend's ground squirrel densities were monitored in the BOPA using fixed trapping grids for 7 years (Smith and Johnson 1985). However, fixed trapping grids only monitor population trends at a specific trapping site. They cannot be extrapolated to larger areas unless we know that an increase in one area will be representative of the region as a whole. Consequently, censuses of burrow entrances (hole count transects) were conducted on the BOPA in 1977-79 and, more comprehensively, in 1982 (Nydegger and Smith 1896 unpubl. data).

Several observers have had the subjective impression of a decline in TGS populations in the BOPA since 1982 (M. Kochert, pers. commun.). Because of the importance of TGS to raptor populations, it seemed worthwhile to redo as many of the 1982 hole count transects as possible in an attempt to assess the current status of Townsend's ground squirrels in the BOPA.

Nydegger and Smith (1986) devoted considerable effort to the estimation of TGS densities using line transect censuses and analyses using the TRANSECT computer program (Burnham et al. 1980). However, they also used a conventional belt transect wherein all burrow entrances in a 5 m wide strip were counted. A secondary goal of this study was to further evaluate the 2 methods.

STUDY AREA

The study was conducted within the northwestern portion of the BOPA. See U.S. Dep. Inter. (1979) for a description of the BOPA. For logistical reasons, we could not redo all 207 of the 1982 censuses. Consequently, we confined our study to the northwestern portion of the BOPA (transects east of Robinson Road, north of the Snake River and the Grandview Highway, west of Simco Road, and outside of the Idaho National Guard Maneuvering and Firing Area).

METHODS

In 1982, 207 hole count transects were randomly established in various vegetation cover types in the BOPA. Vegetation data were recorded using Daubenmire's (1959) canopy-coverage method. Vegetation cover types were named for the dominant shrubs present on the transect. If no shrubs were present, Nydegger and Smith (1986) termed the vegetation type "grass," although in some cases no grasses were present. We have designated this cover type "exotic annuals" since this better reflects reality.

Transects were located in communities by big sagebrush (Artemisia tridentata), winterfat (Ceratoides lanata), and schadscale (Atriplex confertifolia). Some communities were co-dominated by big sagebrush and winterfat, or shadscale and winterfat. These latter were lumped under the most dominant shrub to keep our analysis consistent with 1982. Many transects were located in early seral communities dominated by exotic annuals such as cheatgrass (Bromus tectorum), tumble mustard (Sisymbrium altissimum), pinnate tansy mustard (Descurania pinnatifida), peppergrass (Lepidium perfoliatum), and remnant bunch grasses such as Sandberg's bluegrass (Poa secunda). These exotic annual-dominated communities appear to be forming low diversity, fire dysclimaxes (Yensen 1980). One community in this category was dominated by crested wheatgrass (Agropyron spicatum).

We recensused 60 of the transects used in 1982. In addition, we censused 16 transects in cooperation with a study by Craig Groves (Idaho Natural Heritage Program) on effects of fire on small mammal populations. We also censused 5 transects which were established in 1982, but for which 1982 data were not available. Thus we had 60 transects available for 1982-1986 comparisons and either 65 or 81 transects for vegetation type comparisons. Craig Groves' vegetation data were collected using a plot frame method (Floyd and Anderson 1982) and may not be strictly comparable. We did not try to use those data in this report.

The 1982 transect locations had been marked on topographic maps. We used the 1982 study's topographic maps and field notes to get as close as possible to the location of each 1982 transect. We marked the starting point for each transect with a steel fence post and used a compass to follow the transect direction marked on the map. A 400-m transect was established by pacing and marked with flagging.

Vegetation data were collected using 40 1-m^2 quadrants spaced every 10 m along the 400-m transect (Daubenmire 1959). Percent cover for each species was estimated at each of the 40 points.

TGS were censused using 2 methods. First, we did a line transect (sensu Burnham et al. 1980) density estimate. In this method, the observer carried a pole made of PVC pipe. The flexible pole had light chains approximately 1 m long at either end and spaced such that when the pole was carried level the natural bending of the pole brought the chains to exactly 5 m apart. The chains helped delimit the strip transect boundaries. The observer walked the centerline of the transect and recorded the perpendicular distance from the centerline to all active TGS burrow entrances. Except to make measurements, the observer did not leave the centerline and did not count burrows beyond 2.5 m on either side of the centerline. The strip census was thus 400 m long and 5 m wide (= 2000 m^2). The observer also recorded the number of inactive TGS burrows and the number of active and inactive badger digs.

Next, we did a belt transect. The observer worked systematically back and forth within the 5 m belt searching for and recording all active and inactive TGS burrow entrances in the 400-m transect (2000 m^2). In 1982, this was termed a "pole transect," and consisted of a 600 foot long (183 m) by 5 m wide strip transect (total area 914.4 m^2). In order to facilitate comparisons, we converted both the 1982 and 1986 results to TGS burrow entrances per hectare, or in some cases per 60 ha.

In 1982, all line transect data were grouped by vegetation type and analyzed using the TRANSECT computer program (Burnham et al. 1980). In 1986, the line transect data were also analyzed by cover type and the transects with over 20 burrow entrances were also analyzed individually. We then compared the TRANSECT results to belt transect counts. Because of uncertainties about assumptions made in the 1982 TRANSECT analyses, we made no attempt to compare 1982 and 1986 line transect data and used only belt transect and pole counts for between-year comparisons.

RESULTS

Belt Transect Densities

We compared the hole count densities from our belt transect counts with the 1982 pole counts. During the 4 year period, the number of burrow entrances increased on 10 transects, decreased on 46, and 4 had no active TGS in either year (Table 1). Of the transects with increases, 5 were in winterfat, 3 were in sagebrush, and 2 were in exotic annuals. The mean increase for these transects was 56.1 active burrows/ha (37%).

Overall, however, the results showed a dramatic decline in the number of active TGS burrow entrances, from 11,024 per 60 transects (= 60 ha, mean density = 183.7 active holes/ha) in 1982 to 4,955 per 60 transects (= 60 ha, mean density of 82.6 active holes/ha) in 1986 (Table 1). This represents a 55% decline over the 4 year period. This decline was statistically significant (Wilcoxon signed ranks test, $ts = -5.75$, $df = 59$, $p < 0.001$).

Not surprisingly, there was a high positive correlation (Spearman rank correlation, $rs = 0.777$, $p < 0.01$) between the number of active TGS burrows and active badger digs in 1986. The number of active badger digs also

Table 1. Comparison of 1982 "pole transects" and 1986 belt transects of Townsend's ground squirrel burrow entrances in the Snake River Birds of Prey Area, Ada and Elmore Counties, Idaho. Vegetation cover type acronyms are as follows: CELA = winterfat, ARTR = big sagebrush, ATCO = shadscale, EXAN = exotic annuals (mostly cheatgrass and mustards but sometimes with Sandberg's bluegrass), AGCR = crested wheatgrass. See text for scientific names.

No.	Transect No.	Veg. Type 1982	Veg. Type 1986	Burrows/ha 1982	Burrows/ha 1986
1	4	CELA	CELA	735	315
2	5	CELA	CELA	131	230
3	6	CELA	CELA	232	180
4	7	CELA	CELA	373	260
5	8	ARTR	EXAN	141	165
6	13	CELA	CELA	624	370
7	14	CELA	CELA	342	100
8	15	CELA	CELA	453	150
9	16	CELA	CELA	322	340
10	17	CELA	CELA	201	130
11	18	CELA	CELA	322	340
12	19	CELA	CELA	121	130
13	20	CELA	CELA	60	55
14	21	CELA	CELA	60	25
15	22	AGCR*	ARTR	483	35
16	23	ARTR	ARTR	70	40
17	24	ARTR	ARTR	131	35
18	26	EXAN	EXAN	584	5
19	33	ARTR	EXAN	101	70
20	34	ARTR	ARTR	242	30
21	35	ARTR	EXAN	322	120
22	50	ARTR	EXAN	393	105
23	51	ARTR	EXAN	111	45
24	52	ARTR	ARTR	30	65
25	53	ARTR	ARTR	121	15
26	54	EXAN	EXAN	201	15
27	55	ARTR	EXAN	262	20
28	56	CELA	CELA	363	270
29	57	CELA	CELA	201	180
30	58	ARTR*	CELA	161	425
31	121	ARTR	ARTR	121	170
32	122	ATCO	EXAN	0	0
33	123	ATCO	EXAN	20	0
34	124	ATCO	EXAN	0	25
35	125	ATCO	EXAN	0	0
36	126	ATCO	EXAN	0	0
37	127	ATCO	EXAN	252	0
38	128	ATCO	EXAN	50	0
39	147	ATCO	EXAN	101	5
40	148	ATCO	EXAN	50	5

Table 1. Continued.

No.	Transect No.	Veg. Type 1982	Veg. Type 1986	Burrows/ha 1982	Burrows/ha 1986
41	149	ATCO	ATCO	111	0
42	150	ATCO	EXAN	10	5
43	151	ATCO	EXAN	0	0
44	152	ATCO	EXAN	30	0
45	160	ATCO	EXAN	70	40
46	161	ATCO	EXAN	10	0
47	162	ATCO	EXAN	232	30
48	165	ARTR	ARTR	30	60
49	172	ATCO	ATCO	141	90
50	182	ATCO	EXAN	50	30
51	183	ATCO	EXAN	40	0
52	185	CELA	EXAN	60	0
53	200	AGCR*	EXAN	222	25
54	201	EXAN	EXAN	333	20
55	202	EXAN	EXAN	796	75
56	203	EXAN	EXAN	70	65
57	204	ATCO	ATCO	50	20
58	205	CELA	CELA	141	10
59	206	CELA	CELA	81	15
60	207	ATCO	ATCO	60	0
				11,024	4,955

* We suspect that this stand was misclassified in 1982.

declined between 1982 and 1986 from 80.6 ha to 20.9 ha (74% decrease). This decrease was statistically significant (Spearman signed ranks test, $ts = -4.79$, $df = 59$, $p < 0.001$). Thus the badger decline paralleled that of their major prey.

Winterfat is clearly the cover type with the highest TGS densities (Table 2). It has approximately 4 times as many burrows/ha as big sagebrush, over 6 times as many as exotic annual communities, and over 12 times as many as shadscale. These differences in TGS densities in different cover types are statistically significant (Kruskal-Wallis test, adjusted $H = 17.578$, $df = 2$, $p < 0.001$; shadscale was omitted because of the small sample size).

TGS active burrow entrance densities decreased in all cover types (Table 3). The decreases in density were lowest in winterfat (-28.4%), higher in sagebrush (-63.4%) and shadscale (-69.6%) and exotic annuals (-76.8%), and very high in stands that had burned in the last 4 years (-87.7%).

The role of exotic annuals, particularly cheatgrass, was investigated further by comparing percent canopy cover of cheatgrass (from all vegetation types) with TGS burrow entrance densities. The percent cover of cheatgrass was arbitrarily divided into 3 categories (less than 30% cover, 30-50% cover, and over 50% cover). This analysis shows a striking decline in TGS burrow entrances as cheatgrass cover increases (Table 4). This analysis was repeated using combined percent canopy cover of 7 species of exotic annuals (cheatgrass, tumble mustard, pinnate tansy mustard, peppergrass, tumbleweed, bur buttercup, and storksbill). Again, the results are similar (Table 4). There is an inverse relationship between amount of exotic annual cover and the density of TGS burrows.

Twenty-four of the 60 transects have burned in the past 4 years (40%) (Table 5). Range fires have burned disproportionately in shadscale communities. Communities of exotic annuals without shrubs have replaced 1 of the 17 winterfat communities, 5 of the 12 big sagebrush communities, and 11 of 12 shadscale communities. In so doing, the number of transects dominated by exotic annuals has increased from 5 to 30. We do not know if the percent cover of exotic annuals has changed on specific transects or not.

Cluster Sizes

It seemed possible that since ground squirrels make multiple burrow entrances, the appropriate census unit might be clusters of burrow openings rather than individual burrow openings. Consequently, we recorded the number of openings in a cluster while doing the belt transects. A cluster was a group of burrow openings that were much closer to each other than other burrow openings and in no case were the most distant openings of a cluster more than 1 m apart.

On all transects combined, 82.6% of the clusters were single openings, 13.7% had 2 openings, 2.6% had 3 openings, 0.7% had 4 openings, 0.2% had 5 openings, and 0.1% had 6 openings. The same pattern was seen in all cover types. Thus we concluded that a simple count of total individual active burrow openings is adequate and keeping track of clusters does not improve

Table 2. TGS burrow entrance densities ($\bar{x}$ holes/ha) in 4 major vegetation types in the BOPA in 1986. N is the number of transects in each vegetation type.

Veg. Type	N	Active TGS	Inactive TGS	Active Badger	Inactive Badger
Winterfat	17	201.5	91.0	52.0	141.5
Big sagebrush	9	55.0	32.0	8.0	43.5
Exotic annuals	35	31.5	25.5	10.0	36.0
Shadscale*	4	16.5	26.5	3.5	18.5

* These 4 transects each had <15.5% shrub cover.

Table 3. Decrease in TGS burrow entrances/60 ha between 1982-1986 by cover type. Exotic annuals (1) indicates transects that were dominated by exotic annuals in 1982 and in 1986. Exotic annuals (2) indicates transects that were either winterfat, sagebrush, or shadscale in 1982 and burned in 1982-1985.

Cover Type	N	1982	1986	% Decrease
Winterfat	18	4923	3525	28.4
Sagebrush	8	1278	450	63.4
Shadscale	4	362	110	69.6
Exotic annuals (1)	5	1622	200	87.7
Exotic annuals (2)	25	2889	670	76.8
	60	11024	4955	55.1

Table 4. TGS burrow entrance densities ($\bar{x}$ holes/ha) at increasing densities of cheatgrass (Bromus tectorum) and 7 species of exotic annuals (see text for list). Data from 65 transects in 1986.

Percent Cover	Active TGS per Hectare	Inactive TGS per Hectare
Bromus tectorum		
<30%	107.0	54.5
30-50%	27.5	23.5
>50%	14.5	17.5
all exotic annuals		
<30%	125.0	127.0
30-50%	66.0	35.5
>50%	16.0	19.5

Table 5. Comparison of TGS burrow entrance densities per hectare using belt transects and line transects (program TRANSECT) on 11 individual transects with >20 burrows/transect and on transects grouped by cover type. All data from 1986. SE = standard error.

Transect No.	Cover Type	Belt Count	Transect Estimate	Transect SE
4	CELA	315	4778	804.3
5	CELA	230	5240	807.2
6	CELA	180	4755	1034
7	CELA	260	.1033 E05	
13	CELA	370	6199	910.8
16	CELA	340	7568	1703
18	CELA	340	9332	2412
35	EXAN	120	5969	1961
56	CELA	270	8296	2333
57	CELA	180	5978	880.3
121	ARTR	170	4472	971.4
Cover Type 1			2262	127.8
Cover Type 2			363	32.5
Cover Type 3			868	146
Cover Type 4			715	96

the census. The number of clusters may be indicative of recruitment or other factors however, and should be investigated further.

Line Transect Analysis

The 1986 line transect data were analyzed using the TRANSECT computer program (Burnham et al. 1980). We made all comparisons using the Fourier series estimator, which was necessary since our data was truncated at 2.5 m perpendicular to the transect line. Comparisons of densities from belt transect counts and TRANSECT estimators are shown in Table 5. At this time there appear to be serious problems with the density estimates from the TRANSECT program.

We did, however, investigate the detectability of active TGS burrow entrances using the 2 types of censuses. The systematic searches on the belt transect censuses ideally should detect all burrow entrances in the 5-m-wide strip. Conversely, the number of burrow entrances detected by an observer moving along a fixed transect line should decrease as a function of burrow distance away from the transect line (Burnham et al. 1980).

The line transect censuses detected 57.6 to 97.8% of the burrow entrances later found by searching the 5 m-wide strip (Table 6). The average detectability was 74.2% per transect. The detectability varied slightly between cover types (Table 7). TGS burrow entrances may have been less detectable in exotic annuals because late in the season when the counts were made, cheatgrass and exotic mustards reached maximum height and may have obscured the burrow entrances. There is probably a strong seasonal component in detectability in this habitat type.

The results of the belt transect and the line transect censuses were highly correlated ($r = 0.825$, $df = 6$, $p < 0.05$), which is not surprising given the high degree of autocorrelation. The regression equation ($Y = 0.61X + 5.89$) indicates that the line transects detected about 60% of the burrows found on the belt transects.

The line transect results were used to generate a coefficient of detectability (C.D.) (Emlen 1971) (Figs. 1 and 2). The 18 winterfat transects had 499 burrow entrances. Extrapolation of the count in the 0-50 cm basal strip to the 250 cm cutoff point resulted in an estimate of 805 burrow entrances and a C.D. of 62.1%. The belt transect total was 696. Thus, either the belt transects underestimated, or the C.D. overestimated, the number of burrow entrances by 13%. With the exotic annual transects, the C.D. was similar (62.4%), but in this case the 2 estimates agreed within 2.4%. Sample sizes were too small to repeat the analysis with big sagebrush and shadscale cover types.

Belt transects 5 m wide and 400 m long appear to be faster, more economical, and perhaps just as accurate as more elaborate line transect techniques. Further testing of the two methods should be conducted in areas with known ground squirrel densities. The 1982 pole transects and the 1986 belt transects should both be reasonably accurate for between year comparisons.

Table 6. Variation in detectability of active burrow entrances on individual transects with more than 20 burrow entrances in the BOPA. The total number of burrow entrances detected by the line transect method and by the belt transect were used to calculate the percentage detected by line transects. This assumes that the belt transect detected all burrow openings present.

Transect No.		Cover Type	No. Burrow Openings		% Detected
			Line Trans.	Belt Trans.	
1	4	CELA	49	63	77.8
2	5	CELA	45	46	97.8
3	6	CELA	31	36	86.1
4	7	CELA	31	52	59.6
5	13	CELA	71	74	95.9
6	16	CELA	45	68	66.2
7	18	CELA	34	59	57.6
8	56	CELA	33	54	61.1
9	57	CELA	25	36	69.4
10	58	CELA	60	85	70.6
		subtotal	424	573	74.0
11	121	ARTR	24	34	70.6
12	35	EXAN	20	24	83.3
		total	468	631	74.2

Table 7. Variation in detectability of active burrow entrances in different cover types in the BOPA. The total number of burrow entrances detected on all transects of a given cover type were added. Totals of the line transect method and belt transects were used to calculate the percentage detected by line transects. This assumes that the belt transect detected all burrow openings present.

N	Cover Type	No. Burrow Openings		% Detected
		Line Trans.	Belt Trans.	
18	CELA	499	696	71.7
8	ARTR	64	90	71.1
4	ATCO	11	22	50.0
30	EXAN	106	174	60.9

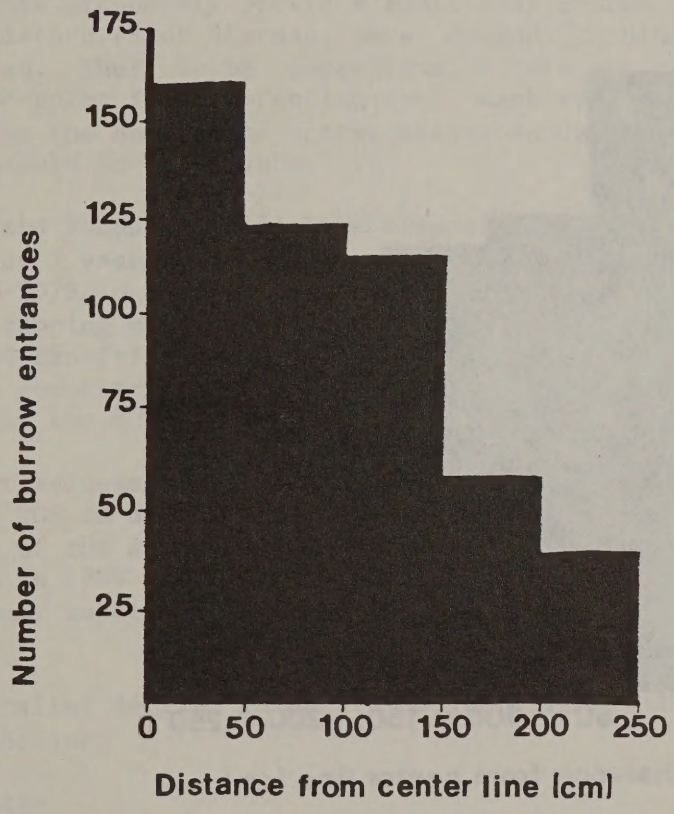

Fig. 1. Detectability of burrow entrances at increasing distances from transect line based on 18 transects in winterfat communities.

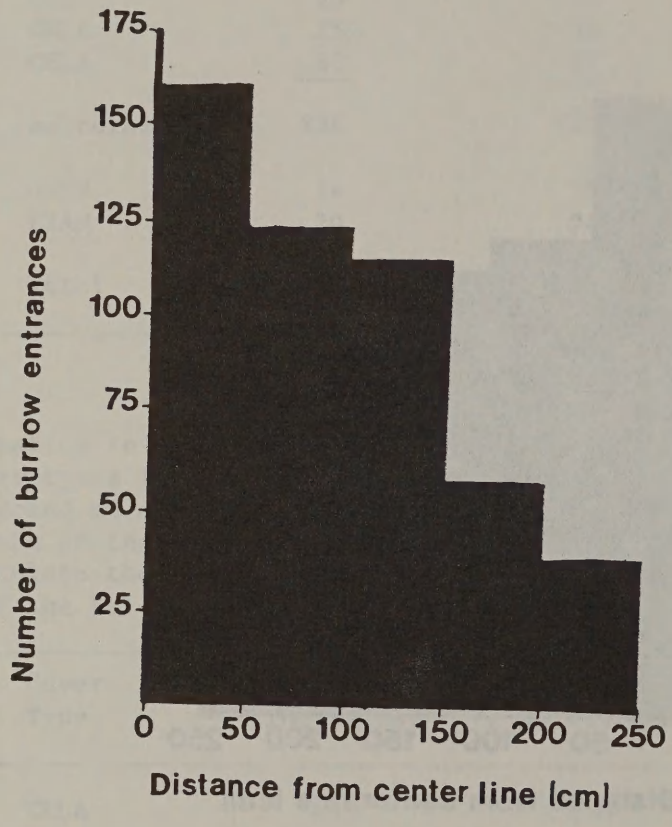

Fig. 2. Detectability of burrow entrances at increasing distances from transect line based on 30 transects in exotic annual communities.

DISCUSSION

The Hole Count Transects

The relationship between the number of burrow entrances and the number of TGS is not known precisely. A single burrow may have multiple entrances, but presumably not more than 1 adult TGS per burrow system. In addition, auxiliary burrows lacking nests may be constructed near the feeding areas (Alcorn 1940).

Whatever the exact relationship is between the number of squirrels and burrow entrances, it seems reasonable that there is a direct relationship between the number of burrow entrances in an area and the number of squirrels constructing burrow entrances in that area. Thus hole count transects should provide an index of TGS populations, but not an absolute census.

Belding ground squirrels (S. beldingi) increase the number of burrow entrances around their maternal burrows about the time the young are weaned. This presumably provides additional routes for young squirrels to escape predators (Paul Sherman, pers. commun.). Other ground squirrels may do this also. Thus, to be comparative, hole count transects should be done at the same point in the breeding cycle each year. The hole count transects were done at the end of the active season in June and July in both 1982 and 1986 and should be comparable.

Smith and Johnson (1985) live trapped TGS on 5 1-ha trapping sites in the BOPA for 7 years. Nydegger and Smith (1986) used this data for the years 1975-1979 to compare live-trapping results with hole-count transects on the 5 trapping sites. They found that hole count transect results and average TGS densities were significantly correlated ($r = 0.94$, $p = 0.002$). Thus, hole count transects seem to be reliable estimators of relative TGS abundance in the BOPA.

Further evidence that the method is probably reliable is provided by the decline of TGS in diets of nesting prairie falcons in the BOPA. The percentage of the diet of nesting prairie falcons comprised by TGS decreased from 36.5% in 1984 to 29.7% in 1985, and to 21.6% in 1986 (see prairie falcon annual report). This may suggest independent corroboration of these results.

The parallel decline in active badger digs is additional evidence of a true TGS decline.

TGS Densities

There are at least 3 possible explanations for the decrease in TGS densities. 1) Previous die-offs of TGS are known (reviewed in Rickart 1987). We may be witnessing an epizootic. 2) Normal population fluctuations as a result of changes in food supply or weather patterns could be responsible. 3) Conversion of desert shrub habitat types could be detrimental to TGS either by reducing cover or by providing inadequate nutrition. We will examine these possibilities in turn.

Epizootics

Svihla (1939) reported a drastic population decline in TGS at Kennewick, Washington. The TGS were abundant in 1933, but declined until none could be found in 1938. He speculated that bubonic (=sylvatic) plague was responsible since it was known to occur in the Washington ground squirrels (S. washingtoni) at Lind, Washington, 104 km away. Hansen (1956) reported a "die-off" of TGS occurred in Utah and Nevada at the same time as the one in Washington. In this case, the "die-off" was widespread and the TGS still had not recovered in numbers or distribution 18 years later. Hansen speculated that sylvatic plague (not native to North America) may have spread into Utah at that time, causing the "die-off." Messick et al. (1983) noted the presence of the plague organism, Yersina pestis, in the BOPA.

No epidemiological studies on TGS have been conducted in the BOPA for several years. If we are witnessing a die-off similar to the one in Utah from which the TGS populations have not recovered, this would have serious consequences for the raptor populations in the BOPA.

Population Fluctuations

Smith and Johnson (1985) estimated an overwinter survival rate of 28% for TGS on the BOPA. Obviously, even a small change in overwinter survival could have a drastic effect on TGS demography. The winters of 1983-84, 1984-85, and 1985-86 have had unusually long periods of snow cover, and many ranchers, farmers, and other people familiar with ground squirrels have told EY that Townsend's, Columbian (S. columbianus), Belding, elegant (S. elegans), and Idaho (S. brunneus) ground squirrel populations have been low for about the last 3 years, which corresponds to personal observations.

No demographic studies on TGS were conducted in the BOPA during the 1982-1986 period. Thus, data on TGS overwinter survival is lacking.

There are no data on the availability of food for TGS in the BOPA during the 1982-1986 period. Thus we cannot rule out the possibility that the observed TGS decline is partially a result of weather and/or fluctuating food availability. If we are observing a normal population fluctuation as a result of long-term weather patterns, the trend should reverse itself and the populations should return to normal in time.

The Interaction Between Vegetation and TGS Densities

Although we do not have data to allow us to evaluate the effect of epizootics and weather, our data do allow us to reach some conclusions about the effect of vegetation changes on TGS in the BOPA.

Our results and the results of Nydegger and Smith (1986) have both shown that winterfat communities support much denser TGS populations. This is probably a result of winterfat's high palatability. Winterfat communities usually also contain moderate cover of native grasses, particularly Poa secunda, and thus provide a diverse, stable food source with shrub cover.

Shadscale communities on the other hand do not seem to be good TGS habitat. South of the Snake River S. townsendii mollis and antelope ground squirrels (Ammospermophilus leucurus) occur in shadscale communities. These taxa may be better adapted to salt desert conditions than S. townsendii idahoensis.

The data have shown that, overall, TGS populations are down to about half the 1982 levels. Even though vegetation changes (=fire) do have an effect, there is clearly some other cause, such as weather or epizootics, operating. There is circumstantial evidence that decreased overwinter survival is the primary factor, since populations of 5 species of local ground squirrels have had low population levels in recent years. However, the effects of the primary factor are clearly being made worse by fires and resulting vegetation changes in the BOPA.

However, most of the recently burned communities were shadscale communities which had few TGS in 1982. If the fires had burned in winterfat communities, the TGS decline might have been even more pronounced.

Fires per se have no direct effect on TGS since they usually occur later in the summer, after the TGS are in estivation. Fires, however, kill shrubs and native forbs which are replaced by exotic annual communities. Reduced shrub cover would make TGS more vulnerable to predation. Reduced shrub cover would also have microclimatic effects, making the habitat more vulnerable to drying and possibly shortening the growing season. Also, exotic annual communities have lower species diversity and may be nutritionally inferior. TGS eat cheatgrass (Smith and Johnson 1985), but this is not assurance that they prefer it. The high palatability of winterfat and the admixture of native grasses in winterfat communities may be responsible for the high densities of TGS found there.

The decline in TGS densities was highest in areas that were dominated by exotic annuals in 1982 (Table 3). We hypothesize that squirrels may persist in an area for a few years after a fire, but the numbers gradually decline to low levels.

Whatever the primary cause of the TGS population decline, the results of this study do not support the notion that cheatgrass and/or exotic annuals provide good TGS habitat. The loss of native shrub habitats in the BOPA does not appear compatible with the maintenance of dense raptor populations. We feel that the reasons for the TGS decline should be investigated in the next field season. Even if TGS populations rebound, differential rebound in the various cover types should be carefully monitored.

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We thank the Boise District, U.S. Bureau of Land Management for logistical support. M. Kochert, K. Steenhof, and L. Young were particularly helpful with many aspects of the study. D. Yensen provided information on the 1982 censuses. We thank Anthonie Holthuijzen for valuable discussion. We especially appreciate the help of K. Steenhof with the TRANSECT program.

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TITLE: Mycorrhizal infection of shrub seedlings planted in burn sites in the Snake River Birds of Prey Area.

INVESTIGATOR: Marcia Wicklow-Howard, Biology Department, Boise State University

COOPERATOR: Boise State University

OBJECTIVE: To monitor the status of mycorrhizae in seedlings planted in a 1985 burn area following 8 months of growth.

ANNUAL SUMMARY

Roots from 5 shrub species were sampled for mycorrhizal root infections in Spring 1986 prior to planting. Of the 5 shrub species, 4 were mycorrhizal negative (big sagebrush, winterfat, Kochia, and rabbitbrush) and 1 was mycorrhizal positive (four-wing saltbush).

METHODS

Prior to planting at the burn area, fine roots from randomly selected shrub seedlings were collected, fixed in FAA, and cleared and stained with trypan blue, according to the procedure of Phillips and Hayman (1970). The roots were than examined for the present of VA mycorrhizal propagules. Ten roots from each shrub species were examined. The plants from which these root samples were taken were marked to enable easy recognition at the shrub plantation area. Following 8 months of growth, roots from these plants were again collected and processed in the manner described above.

Within the plantation area 20 seedlings, split between the high and low intensity site, of each shrub type have been tagged and numbered. These will be examined with respect to 2 aspects: mycorrhizal root infection and estimate of above-ground shrub growth. Comparisons will be made between mycorrhizal infectivity, burn type, and above-ground growth. The results for this phase of the work are still pending.

RESULTS

The results from preliminary seedling studies are presented in Table 1. Four-wing saltbush (Atriplex canescens) seedlings have maintained the mycorrhizal positive status originally assigned and were observed to have produced even greater quantities of mycorrhizal propagules. Of the other shrub species, only winterfat (Ceratoides lanata) roots have become infected during the 8-month growth period. From the specimens sampled, the big sagebrush (Artemisia tridentata), Kochia, and rabbitbrush Chrysothamnus appear to have formed no VA mycorrhizal associations.

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Table 1. Mycorrhizal status of seedlings planted at burn sites.

	April 1986	November 1986
Four-wing Saltbush	+ (vesicles)	+ (internal vesicles, hyphae external vesicles, and arbuscules)
Winterfat	-	+ (hyphae, external vesicles, and arbuscules)
Wyoming Big Sage	-	-
Kochia	-	-
Rabbitbrush	-	-

+ = mycorrhizal positive
- = mycorrhizal negative

TITLE: Vegetation Monitoring in the Snake River Birds of Prey Area.

INVESTIGATORS: Ray Aguilar, Range Conservationist, Bruneau Resource Area
Lisa Pickford, Fire Crew
Steve Biatowas, S.C.A. Volunteer

OBJECTIVE:

To monitor changes in vegetation in the Birds of Prey Area as related to livestock grazing and wildfires.

ANNUAL SUMMARY

Four of 8 fire study plots were sampled and a shadscale control fire study plot was established in 1986.

METHODS

Exclosures and Fire Study Plots

Three new paired study plots were established in 1983, as controls to supplement the 5 pairs established in 1982. Control pairs were placed at the Big Sagebrush Spring/Fall exclosure, Winterfat exclosure and the Shadscale exclosure. A new paired study plot was established in 1986 to replace one which burned in June 1985. Like the previously established plot pairs, each plot consisted of 3 permanently marked 100 ft. (30.5 m) transect lines in a radial arrangement with a common origin. Each plot consisted of 2 of the radial triads. One triad of each pair was located inside the respective exclosure to prevent livestock grazing; the other was located adjacent to but outside the exclosure fence.

Four of 8 fire plots were sampled in June 1986. These included fire plot #4 (CELA exclosure), #6 (CELA control), #8 (ARTR control) and #7 (ATCO control). The newly established fire study plot, #9 (ATCO control), was also sampled in June 1986. This study plot was later destroyed as a result of the July 1986 Dorsey Butte fire and will have to be reestablished in 1987. Established fire plots will continue to be read in the future.

Sixty canopy coverage estimates (Daubenmire 1959) were obtained on each triad (20 per line) at 5 ft. intervals. Twelve 1/300 acre (13.49 m^2) circular plots (Asherin 1973) were used on each triad to record plant density. Each line was photographed. The frequency of occurrence for each species was also calculated for each triad.

RESULTS

Precipitation for the spring of 1986 was above average for the area encompassing the 9 fire study plots (U.S. Dep. Commerce 1986).

After 1986 data had been recorded, the newly established shadscale exclosure burned. The entire exclosure is now burned and will henceforth be used as a study plot for establishing plant species to be used in fire rehabilitation efforts.

All data collected on the fire study plots are located in the Birds of Prey exclosure binder at the Boise District, Bureau of Land Management, Boise, Idaho.

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